DOCUMENT RESUME

ED 363 714 CE 064 931

AUTHOR	Fair, Helena J.
TITLE	Assisting in Radiology/Imaging. Instructor's Guide, Student's Manual, and Student Learning Activities.
INSTITUTION	Texas Univ., Austin. Extension Instruction and Materials Center.
SPONS AGENCY	Texas Education Agency, Austin.
PUB DATE	92
NOTE	161p.
AVAILABLE FROM	Extension Instruction and Materials Center, University of Texas, P.O. Box 7218, Austin, TX 78713-7218 (stock no. HO 220 I, instructor's guide; HO 220 S, student's manual, HO 220 LA, learning activities).
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052) -- Guides - Classroom Use - Instructional Materials (For Learner) (051)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Behavioral Objectives; Citations (References); Classroom Techniques; Competence; Competency Based Education; Course Content; Educational Resources; Individualized Instruction; *Job Skills; Learning Activities; Postsecondary Education; *Radiologic Technologists; *Radiology; Study Guides; Teaching Methods; Tests; Units of Study
IDENTIFIERS	*Medical Imaging Occupations

ABSTRACT

The instructor's guide, the first of three documents in this package, is designed for a course to help students who are investigating the activities within a radiology department or considering any of the imaging technologies as a career. The material is designed to relate training experience to information studied in the classroom. This instructor's manual provides a list of essential elements correlated to the units of instruction. A basic test, answers to tests, and answers to learning activities are included for each unit. The manual also contains a section for students desiring a more advanced study of each unit, and a competency chart. The student's manual, the second of the three documents, is designed for use by students investigating the activities within a radiology department or considering any of the imaging technologies as a career. The student's manual contains learning objectives, terms and definitions, and information relating to current techniques and technologies. Clinical use of radiation, procedures for film loading and development, and types of equipment are presented. Both radiation and biological safety are emphasized. New imagining technologies, such as ultrasound and magnetic resonance, are introduced. The materials in the first two documents are organized in 11 units: the radiologic technologist as a member of the health care team; the production of x-rays; equipment; protection from radiation and infection; radiology office records and procedures; patient care and transportation; radiographic film and the film holder; intensifying screens; radiographic darkrooms; processing radiographs; and artifacts. The student's manual also contains a glossary of 54 radiographic terms and a bibliography listing 14 references. Individualized student learning activities are provided (in the last of the three documents) to encourage students to read and study the information presented in the radiology and imaging course. One or more learning activities are included for each of the 11 course units. Learning materials consist of questions to answer, suggested research activities, matching tests, and labeling activities. (KC)

TX92CD04

ED 363 714

Assisting in Radiology/Imaging

Instructor's Guide

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Assisting in Radiology/Imaging

Instructor's Guide

By

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Published by

The University of Texas at Austin
Educational Resources
Extension Instruction and Materials Center
Division of Continuing Education

Developed under a contract with

Texas Education Agency
Austin, Texas

1992

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Printed in the United States of America

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Additional copies may be ordered from:

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Stock Number HO 220 I

Contents

Foreword....................iv

Acknowledgments....................v

Essential Elements Addressed by Units
in *Assisting in Radiology/Imaging*....................vi

Answers to Learning Activities....................1

Tests....................15

Answers to Tests....................39

For More Advanced Study....................47

Suggestions for Answers to "For More Advanced Study"....................51

Competency Chart....................55

Bibliography....................57

Foreword

Assisting in Radiology/Imaging is designed for use by students investigating the activities within the radiology department or considering any of the imaging technologies as a career. The material is designed to relate training experience to information studied in the classroom. Information is provided which is current and relevant to the essential elements approved by the Texas State Board of Education, 1988. The material is designed for individualized study and is competency-based with objectives or outcomes stated for each unit. *Assisting in Radiology/Imaging* is made up of three separate publications.

- The *Student's Manual* contains learning objectives, terms and definitions, and information relating to current techniques and technologies. Clinical use of radiation, procedures for film loading and development, and types of equipment are presented. Both radiation and biological safety are emphasized. New imaging technologies, such as ultrasound and magnetic resonance, are introduced.

- The *Student Learning Activities* are individualized and designed to encourage the student to carefully read and study the information presented. Instructors are encouraged to provide one set for each student to facilitate learning.

- The *Instructor's Guide* provides a list of essential elements correlated to the units of instruction. A basic test is provided for each unit. Instructors are encouraged to enlarge these. Answers to tests and learning activities are included. A section has been added for those students desiring a more advanced study of each unit. A competency chart is included.

Acknowledgments

The Extension Instruction and Materials Center wishes to acknowledge with grateful appreciation the cooperation and assistance of the following health occupations teachers and professionals who served as members of the 1991-92 Health Occupations Project Advisory Committee:

- Jeanne Ballard, Education Coordinator for the Medical Laboratory, Seton Hospital, Austin, Texas
- Gail Beard, former HOE Educator, Houston, Texas
- Pam Buchanan, Lecturer for Kinesiology and Health, The University of Texas at Austin
- Fran Donohue, Health Occupations Educator, Victoria High School, Victoria, Texas
- Brenda Luckie, Coordinator for Ancillary Services, Student Health Center, The University of Texas at Austin
- Linda Montgomery, Health Occupations Educator, Brenham High School, Brenham, Texas
- Ann O'Sullivan, Radiology Technologist, Capital Radiology, Austin, Texas
- Carolyn Ragland, Instructor, Austin Community College, Riverside Campus, Health Sciences/Medical Laboratory Technology, Austin, Texas
- Judy Rose, Health Occupations Educator, Stephen F. Austin High School, Austin, Texas
- Barbara Selke-Kern, Director, Educational Resources, EIMC, The University of Texas at Austin
- Spanky Stephens, Head Athletic Trainer, Men's Intercollegiate Athletics, The University of Texas at Austin

Special thanks go to the Radiology Department, Memorial Medical Center of East Texas, Lufkin, Texas, for suggestions to update Table 1, "Preparations for Radiographic Examinations"; to Bev Brack, Radiologic Technologist, Blinn College, Brenham, Texas, for her comments on film size and chart forms; and to Charlotte Rutherford, R.T., Houston, Texas, for information included in the Glossary of Radiographic Terms.

The Center also recognizes with gratitude the support and suggestions provided by Barbara Terrell, State Program Director for Secondary Health Occupations Education, Texas Education Agency, Austin.

Portions of the Student's Manual are adapted from Extension Instruction and Materials Center's 1984 publication, *Assisting in Radiology*, written by Janet Schnauze.

Essential Elements Addressed by Units in *Assisting in Radiology/Imaging*

Below is a list of the units in *Assisting in Radiology/Imaging* that address the Essential Elements as specified in subsection 75.84 (n) and approved by the Texas State Board of Education, January 1988.

(n) Nursing assistant, radiology (2-3 units), shall include the health occupations core and the concepts and skills associated with the occupation of nursing assistant, radiology department. The student shall be provided opportunities to:

		UNIT
(1)	transport patients to treatment units;	6
(2)	assist with robing and disrobing patients;	6
(3)	change linen and clean room;	6
(4)	record pertinent information in the patient's chart;	1, 5
(5)	adjust inventory and supplies as directed;	6
(6)	maintain inventory and supplies as directed;	7, 9, 10, 11
(7)	prepare and maintain work area;	3, 4, 7, 8, 9, 10
(8)	distribute radiograph reports to the appropriate unit for placement on the chart; and	5
(9)	assist in record keeping.	1, 5

Unit 1 contains an introduction to the concepts and skills in occupations associated with radiology and imaging and discusses radiology personnel as members of the health care team.

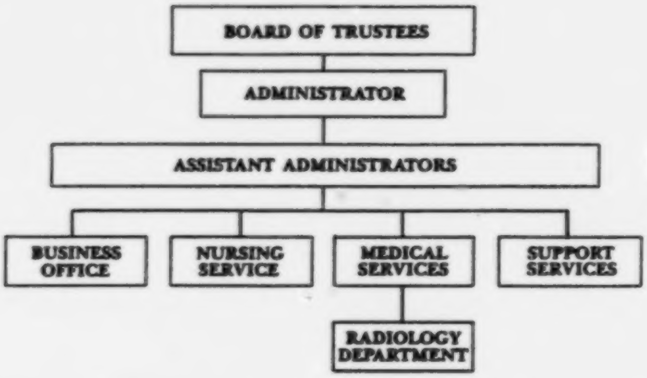
Unit 2 describes properties and production of x-rays.

Answers to Learning Activities

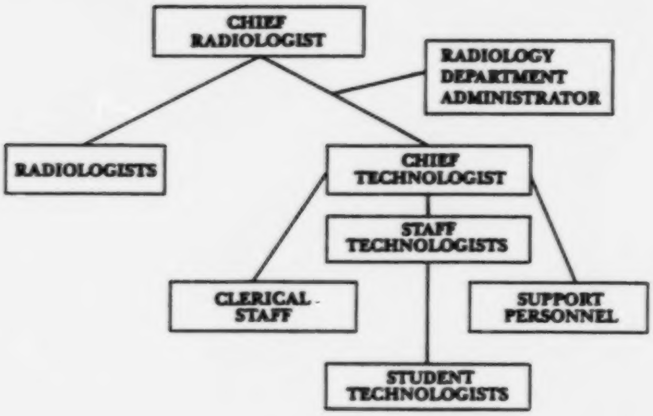
UNIT 1: THE RADIOLOGIC TECHNOLOGIST AS A MEMBER OF THE HEALTH CARE TEAM

Learning Activity 1: Questions to Answer

1. all information concerning the patient that must be kept in confidence
2. never
3. no
4. refer the patient to his doctor
5. to the hospital
6. Explain that the radiographs belong to the hospital.
7. board of trustees
8.


BOARD OF TRUSTEES
ADMINISTRATOR
ASSISTANT ADMINISTRATORS
BUSINESS OFFICE
NURSING SERVICE
MEDICAL SERVICES
SUPPORT SERVICES
RADIOLOGY DEPARTMENT

9. physician, therapists, diagnostic workers, dietitians, social workers, pharmacists, record keepers
10. Names on chart will vary.


CHIEF RADIOLOGIST
RADIOLOGY DEPARTMENT ADMINISTRATOR
RADIOLOGISTS
CHIEF TECHNOLOGIST
STAFF TECHNOLOGISTS
CLERICAL STAFF
SUPPORT PERSONNEL
STUDENT TECHNOLOGISTS

11. aides, orderlies, housekeeping, maintenance (Any two)
12. radiography, nuclear medicine technology, radiation therapy, sonography, magnetic resonance imaging, computed tomography
13. Radiographs are the best diagnostic method for detecting abnormal conditions between the teeth.

Learning Activity 2: Word Recognition

1. j
2. h
3. e
4. c
5. i
6. g
7. f
8. d
9. a
10. b
11. computed tomography
12. magnetic resonance imaging
13. nuclear medicine technologist
14. radiologic technologist
15. radiologic technologist (American Registry of Radiologic Technologists)

Learning Activity 3: Technology Programs

Answers will vary; should be completed to the satisfaction of the instructor.

UNIT 2: THE PRODUCTION OF X-RAYS

Learning Activity 1: Questions to Answer

1. in 1895, by Wilhelm Konrad Roentgen
2. X-rays travel in divergent, straight lines at a speed of 186,000 miles per second.
3. when fast-moving electrons strike a target
4. tungsten
5. Only 0.2% is x-ray energy, and the rest is heat.
6. cathode, anode, glass envelope
7. The anode is the positive terminal, and the cathode is the negative terminal.
8. to guide the electrons to the target
9. for heat dissipation
10. stationary anode tube, rotating anode tube; rotating anode tube is most commonly used
11. MA selector
12. KV selector
13. (1) have short wavelength
    (2) travel in straight lines, diverging
    (3) travel at the speed of light
    (4) are invisible
    (5) cause some substances to fluoresce
    (6) are electrically neutral
    (7) cause biological changes
    (8) produce an image on film

Learning Activity 2: Identification of Parts of the Tube

1. D
2. B
3. E
4. C
5. A
6. F
7. H
8. G
9. stationary anode tube
10. rotating anode tube

UNIT 3: EQUIPMENT

Learning Activity 1: Questions to Answer

1. tube stands, control panel, generator, table
2. to support the x-ray tube so that it can move freely over the patient
3. a. glides in a track on the floor
   b. moves between tracks on floor and ceiling
   c. suspended from a ceiling rack
4. control panel
5. radiation (milliamperage), penetrating ability of the beam (kilovoltage), and exposure time
6. produce high voltage
7. to render body structures visible by contrast in the density of the structure to its surrounding tissues; barium sulfate, iodine, air
8. observation of an x-ray on a screen
9. special radiographs taken during fluoroscopy
10. when the patient is very ill or immobilized and when x-rays are needed in surgery
11. to produce a clear x-ray of areas of the body difficult to demonstrate
12. Godfrey Hounsfield
13. In tomography an x-ray is produced parallel to the long axis of the body. In CT scanning, a cross-sectional image is produced on a television monitor. The image is photographed.
14. CT scanner, MRI unit. The gantry on the MRI unit is much larger with a relatively small tunnel opening for patient entry. The MRI gantry houses a magnet, while the CT scanner has an x-ray tube.
15. anyone with a steel rod implantation, steelworkers, those with pacemakers, and those who are claustrophobic
16. computer, probes, photographing device
17. A *transducer* is a device to convert energy from one form to another. The probe on the ultrasound unit changes electrical impulses to ultrasound waves and gathers information from the reflected sound wave.
18. The crystal in the gamma camera detects gamma rays given off from radioactive substances within the patient's body. The scintillation camera records the gamma rays as flashes of light which are converted into an image. So the camera may be called either.

Learning Activity 2: Word Recognition

1. contrast media
2. image intensifier
3. television
4. remote control
5. tomography
6. gantry
7. computer
8. transducer
9. sonogram

10 scintillation

11. well counter
12. gamma rays
13. frontal/coronal
14. saggital
15. axial/transverse

Learning Activity 3: Comparison of Technologies

1.

	Name	*Type*
a.	x-ray, radiograph	x-ray
b.	spot films	x-ray
c.	tomogram	x-ray
d.	tomogram, scan, image	photograph
e.	image	x-ray
f.	sonogram	x-ray, photograph
g.	scintigram, scintiscan	photograph

2. computed tomography, magnetic resonance imaging, sonography

UNIT 4: PROTECTION FROM RADIATION AND INFECTION

Learning Activity 1: Questions on Radiation Safety

1. One type of radiation damage is the genetic effect which damages chromosomes. The other type is the somatic effect whereby cells and tissues are damaged.
2. 35
3. 110
4. using mobile equipment , fluoroscopy
5. film badge, thermoluminescent dosimeter
6. on the collar and under the apron
7. lead, barrier
8. time, distance
9. At double the original distance, the radiation is spread over an area four times larger.
10. apron, gloves, goggles; vinyl or rubber and lead
11. to avoid radiation exposure
12. use sandbags or compression bands, ask a relative to hold the patient
13. Radiation Control for Health and Safety Act, Consumer-Radiation Health and Safety Act
14. Nuclear Regulatory Commission, Food and Drug Administration

Learning Activity 2: Word Recognition

1. k
2. i
3. g
4. c
5. f
6. h
7. e
8. b
9. d
10. a
11. j

Learning Activity 3: Medical Asepsis

1. a. prevention of spread of disease from one person to another
   b a disease which can be spread from one person to another
2. Patients needing medical care are already suffering from infections.
3. indirect—by use of contaminated equipment or objects
   direct—contact between persons
   enteric—transmission of disease by body waste

4. practicing good health habits, getting rest, eating properly, washing hands
5. before and after caring for patients, after toileting, on leaving isolation, after handling soiled equipment , before eating
6. These are donned before taking mobile equipment to isolation and when isolation patients are brought to radiology. Gloves are worn for any invasive procedure.
7. to dispose of them properly
8. One barrier is the shield of radiation-absorbing material (lead) to protect against radiation. The other barrier is formed by gloves, mask, and gowns to protect against the spread of disease.

UNIT 5: RADIOLOGY OFFICE RECORDS AND PROCEDURES

Learning Activity 1: Reception and Records

1. answering telephone, scheduling patients' appointments, explaining examination procedures, and record keeping (Any three)
2. "Radiology Department, and a name"
3. *Verbal* communication is done with words. *Nonverbal* is without words, such as body language.
4. so that they can help the patient with special preparations which must be completed before reporting for the examination
5. a physician
6. Check for any previous radiographs.
7. The radiologist reads the radiograph and dictates a report on the findings. A secretary prepares the report. Copies are made and distributed. The radiograph is filed by case number.
8. four copies—one copy with the patient's radiograph, one copy in a file, one copy to the patient's chart, and one copy to patient's doctor
9. The radiograph is numbered with a series using six numbers, arranged into three groups. The radiographs are filed by the last two numbers, then the first number of the second group.
10. computer
11. alimentary tract, colon, esophagus, feces, gallbladder, small intestine
12. kidney, ureter, urinary bladder

Learning Activity 2: Procedures

1. barium sulfate
2. iodine
3. intravenous pyelogram
4. to x-ray the breast
5. to remove all jewelry, glasses, and hair ornaments for a head scan; to keep patient as still as possible
6. The patient is given radioactive material with a pharmaceutical. This travels throughout the body and concentrates in an organ. The patient is placed before a gamma camera which records the emissions using a scintillation crystal.
7. flushing, metallic taste, itching, shortness of breath
8. High-frequency ultrasound waves are used to break up kidney stones.

9. female pelvic examination
10. gallbladder, urinary bladder, male pelvis, thyroid, knee, heart, blood arteries and veins
11. examination of the heart
12. distinguish blood flow without invasive techniques
13. Choose MRI because it produces more body planes, is faster, and has no radiation exposure. Choose CT scan for bone visualization, people with metal in bodies, and those who are claustrophobic.
14. (1) c (2) d (3) a (4) b
15. a. mammagram
    b. echocardiology, Doppler ultrasound
    c. upper GI series, lower GI series
    d. gallbladder examination, ultrasound
    e. CT scan
    f. echocardiography
    g. CT scan, ultrasound, MRI
    h. CT scan, ultrasound, MRI
    i. ultrasound
    j. nuclear medicine, ultrasound
    k. Doppler ultrasound
    l. IVP, CT scan, ultrasound MRI

UNIT 6: PATIENT CARE AND TRANSPORTATION

Learning Activity 1: Safety for Patients and Workers

1. Check identification bracelet, compare birthdate on request slip to patient.
2. removed from less afflicted side first, placed on afflicted side first
3. prevent injuries, less tiring
4. center of gravity. The line of gravity passes through this point.
5. a. Stand with feet parallel, at right angles to lower legs, and from 4 to 8 inches apart.
   b. Keep knees slightly bent.
   c. Keep buttocks in and abdomen up and in.
   d. Keep work at a comfortable height.
   e. Use smooth, coordinated movements.
6. a. Provide a base of support with the feet separated and one foot slighly ahead of the other.
   b. Distribute weight evenly on both feet.
   c. Keep work close to body to avoid stretching and reaching.
   d. Work at a comfortable height.
   e. Use smooth, coordinated movements.
7. in short, simple commands
8. by stretcher, wheelchair, and patient ambulation
9. a. Place chair facing and close to patient.
   b. Raise foot supports and lock wheels.
   c. Stand in front of patient.
   d. Support patient at sides, pivot with patient, and seat in chair.
10. minimal support, moderate support, more than moderate support

11. Try to break the fall so patient slides easily to floor, and get physician to check patient.
12. a. Ask patient to wait until radiologist can verify that all needed films have been obtained.
    b. Say that another film is needed for diagnosis.
13. Assist patient to dress. Return all personal property. Check records for completeness. Dismiss patient.

Learning Activity 2: Recognition of Words

1. h
2. g
3. d
4. f
5. b
6. i
7. a
8. c
9. e
10. a few inches apart
11. muscle strain
12. shortest
13. lock
14. short, simple
15. line of gravity

UNIT 7: RADIOGRAPHIC FILM AND THE FILM HOLDER

Learning Activity 1: Cross Sections

1. (1) supercoating
   (2) emulsion
   (3) adhesive
   (4) polyester base
   (5) adhesive
   (6) emulsion
   (7) supercoating
2. (1) cassette front (Bakelite)
   (2) felt
   (3) screen
   (4) film
   (5) screen
   (6) felt
   (7) cassette back (metal)

Learning Activity 2: Study Questions

1. base,emulsion
2. a. flexible, blue-tinted polyester support for emulsion; depth of 0.008 inch
   b. film layer to hold emulsion to base
   c. composed of microscopic crystals of silver halide suspended in gelatin; depth of 0.001 inch
   d. protective gelatin layer over film emulsion
3. to reduce the eyestrain for the radiologist
4. silver halide, gelatin
5. Gelatin swells as cold water is added. When the water is heated, more gelatin with silver crystals can be added. As the gelatin cools, the whole solution sets to a jelly, imprisoning the silver salts. When the film is immersed in developer, the gelatin swells so that the solution can act upon the silver.
6. The two types are (1) screen film and (2) nonscreen or direct-exposure film. Screen film is used with intensifying screen for high-speed, good-quality

films. Nonscreen or direct-exposure film has a thicker emulsion, should not be used with intensifying screens, and depends on the direct action of the x-rays. It is used to image small body parts.

7. nonscreen or direct-exposure film
8. a. small film individually packaged in a plastic container that can be sterilized for use in surgery to study kidney function
   b. used in film badges for personnel monitoring
   c. used to copy x-rays; emulsion coating on one side only
9. Film is sealed in a metal foil bag and paper wrappings to protect it from light and moisture. It is packaged in quantities of 25, 75, or 100 sheets. The package is placed in a cardboard carton.
10. Film should be stored in a cool, dry place. Excessive heat can ruin the film. Film must be protected from moisture and other contaminants. Film must be protected from radiation by lead-lined walls or containers. It must not be subjected to pressure, bending, or wrinkling.
11. on the end of the box
12. lightproof container for holding film and intensifying screen
13. front—lightweight metal or plastic; back and frame—aluminum or stainless steel
14. 14" x 17", 11" x 14", 10" x 12", 8" x 10", 61/2" x 81/2", 5" x 7", 7" x 17", 9 1/2" x 9 1/2"
15. to make the cassette lightproof
16. to convert the x-ray energy into visible light
17. Place cassette on loading bench. Lift the back. Keep film straight, and lay it flat in the cassette. Close back, and lock latch.

Learning Activity 3: Word Recognition

1. a
2. b
3. c
4. a
5. b
6. d
7. c
8. b
9. d
10 d
11. c
12. a

Learning Activity 4: Local Facilities

Answers will vary according to the policies of the local radiology department.

UNIT 8: INTENSIFYING SCREENS

Learning Activity 1: Study Questions

1. to convert the energy of the x-ray beam into visible light
2. reduces radiation exposure
3. two
4. cardboard, polyester
5. to reflect light from the phosphor toward the film
6. a shiny substance such as titanium dioxide
7. layer of screen which converts the energy of the x-ray into visible light

9. a. calcium tungstate—blue-violet
   b. barium lead sulfate—blue-violet
   c. rare earth—blue-violet, green
10. speed
11. protect the phosphors from handling
12. type of phosphor used, speed
13. less radiation for patient
14. to give good detail
15. Place a wire mesh on top of a loaded cassette. Make an exposure, and process it. If the image is sharp and well defined, contact is good.
16. warping, loose cassette hinges, worn felt in cassette
17. using special screen cleaner, soap and water, with cotton balls or gauze squares
18. Answers will vary.
19. base
20. reflective layer
21. phosphor
22. protective coating

Learning Activity 2: Word Recognition

1. a
2. g
3. f
4. j
5. h
6. c
7. a
8. b
9. d
10. i
11. e

UNIT 9: RADIOGRAPHIC DARKROOM

Learning Activity 1: Study Questions

1. single-lock door, interlocking door, revolving door (Any two)
2. manual processing tanks, automatic processor, sink (Any two)
3. film bins, transfer cabinets, loading bench (Any two)
4. to minimize static
5. lead in walls and all openings
6. ceramic tile
7. ivory, cream,buff, or pale shades of any color
8. 67° to 78°F, 60 percent humidity
9. Wratten 6B
10. eight times more sensitive to safelight after exposure to radiation
11. A slightly exposed film is placed on the counter and covered with black paper. Each minute, the paper is slipped one inch from the short side of the film. A large lead numeral is placed in the area, with safelight exposing it progressively until it reaches one inch from the opposite side. It is developed to show when graying appears.
12. on end of box
13. Film is expensive and does not produce a good radiograph if used past the expiration date.

14. a. Place lead numerals in film when exposed.
    b. Expose information card and film to small source of white light.
    c. Attach radiopaque tape with information to film before exposure.
15. Drawings will vary with facility.

Learning Activity 2: Word Identification

1. d
2. a
3. g
4. e
5. f
6. b
7. c
8. e

UNIT 10: PROCESSING RADIOGRAPHS

Learning Activity 1: Word Recognition

1. b
2. c
3. a
4. c
5. d
6. a
7. b
8. c
9. c
10. b

Learning Activity 2: Study Questions

1. manual, automatic
2. by temperature and manufacturer
3. five minutes at 68°F
4. developing, fixing, washing, drying
5. shortens processing time, improves quality, increases capacity of department to work
6. film feeding, film processing, dryer
7. transport, water, recirculation, replenishment, dryer
8. a. 95°F b. 95°F c. 120°F
9. transport
10. washes film, keeps solution at correct temperature
11. a. 7" x 17"—two at a time, both short sides first
    b. 11" x 14"—one at a time, long side first
    c. 8" x 10"—two at a time, both short sides first
    d. 10" x 12"—one at a time, long side first
12. Incorrect feeding of the film may cause over-or under-replenishment, resulting in poor quality film development.
13. removal of surface moisture by the rollers
14. Heated air is blown on both sides of the radiograph by a blower.
15. so spacing between rollers can be constant throughout
16. uniform thickness of base and emulsion, noncurling, emulsion not sticky, and less gelatin
17. Clean rollers regularly. Empty and clean developer and fixer tanks after 50,000 films or about every 3 to 4 months. Inspect transport system. Follow manufacturer's directions.
18. c
19. e

20. d
21. a
22. b

Learning Activity 3: Silver Recovery

1. silver halide
2. fixer
3. conservation of a natural resource, increasing profits by selling silver, prolonging the life of the fixer
4. a. metallic replacement—consists of a recovery cartridge and circulating unit to replace silver with another metal
   b. electronic recovery—uses an electric current between positive and negative electrodes placed in fixer tank or fixer collecting tank
   c. chemical precipitation—compounds are added to precipitate silver as a sludge
5. metallic replacement
6. electronic recovery

Learning Activity 4: Chemistry of Processing

1. acetic acid—F, acidifier, stops development
2. aluminum chloride—F, hardener, shrinks and hardens emulsion
3. ammonium thiosulfate—F, fixing agent, dissolves the unexposed, underdeveloped silver crystals on film
4. chrom alum—F, hardener, shrinks and hardens emulsion
5. elon—D, reducing agent, builds up gray tones
6. glutaraldehyde—D, hardener, controls emulsion swelling
7. hydroquinone—D, reducing agent, builds up black tones
8. phenidone—D, reducing agent, builds up gray tones
9. potassium alum—F, hardener, shrinks and hardens emulsion
10. potassium bromide—D, restrainer, keeps reducing agents from causing fog
11. sodium carbonate—D, activator/accelerator, swells and softens emulsion
12. sodium hydroxide—D, activator/accelerator, swells and softens emulsion
13. sodium sulfite—D, preservative, prolongs life of developer
14. water—D and F, solvent, liquid for dissolving chemicals

UNIT 11: ARTIFACTS

Learning Activity 1: Study Questions

1. any foreign or artificial mark on a radiograph
2. carelessness
3. handling, manual processing, automatic processing, and equipment
4. (a) crescent, (b) scratches
5. reticulation
6. Film has greasy or shiny appearance.
7. streaks
8. a line which occurs on film 3.14 times the diameter of the roller away from the leading edge of the film; fresh chemicals
9. a. chemical fog—manual

    b. light streaks, unfastened covers of wet section of processor, contaminated solutions, chemical imbalance (automatic)
    c. light fog caused by loose hinges and worn springs or felt on cassettes (equipment)
    d. light, radiation, chemical, age of film (other)
10. chemical fog
11. oxidized developer
12. inadequate rinsing or using an exhausted fixer
13. kiss marks
14. gritty film
15. wetness, tackiness
16. dust or dirt on the intensifying screen of cassettes
17. poor screen-film contact, defective screens
18. It may have radiation fog from the exposure.
19. causes brittleness
20. the emulsion

Tests

TEST / Unit 1

The Radiologic Technologist as a Member of the Health Care Team

Directions: Match by placing the letter of the definition in the blank next to the term.

_____1. chief technologist

_____2. nuclear medicine technologist

_____3. radiologic technologist

_____4. radiologist

_____5. sonographer

a. assists the radiologist in administering radiation for treatment

b. supervises staff of radiology department

c. doctor using radiation to diagnose and treat disease

d. exposes dental x-rays

e. uses ultrasound equipment to produce pictures for diagnosis

f. prepares patients for examination and treatment and operates x-ray equipment

Directions: Give complete answers to these questions.

6. Define and explain *confidential communication.*

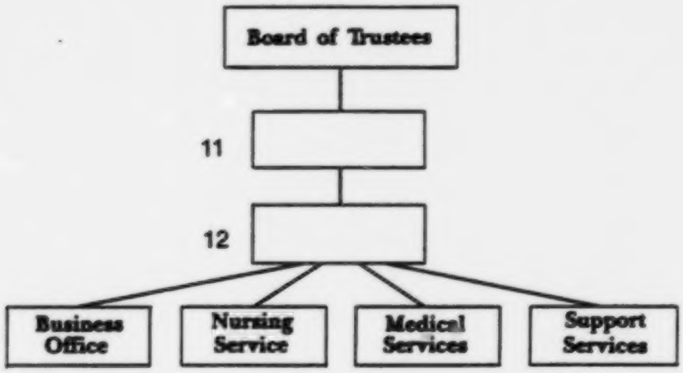
7. To whom do radiographs belong?

8. List three fields, besides radiology, included in radiology/imaging.
    a.
    b.
    c.

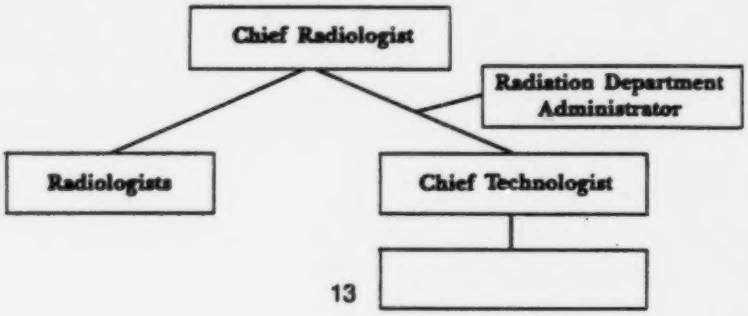
9. Who establishes the policies and goals of a hospital?

10. Name two occupations included in the support staff of a hospital radiology department.
    a.
    b.

Directions: Fill in the blanks on the hospital organization chart.


Board of Trustees
11
12
Business Office
Nursing Service
Medical Services
Support Services

Directions: Fill in the blank on the radiology department organization chart.


Chief Radiologist
Radiation Department Administrator
Radiologists
Chief Technologist
13

TEST / Unit 2

The Production of X-rays

Directions: In questions 1-8, circle the letters corresponding to the correct answer.

1. X-rays were discovered in
   a. 1895 b. 1900 c. 1926 d. 1915

2. X-rays were discovered by
   a. William Coolidge c. Ed Jerman
   b. Thomas Edison d. Wilhem Roentgen

3. X-rays travel at the speed of
   a. 186,000 miles/second c. 186,000 miles /minute
   b. 1,800 miles/second d. 186,000 miles/hour

4. X-rays result from the bombardment of a suitable target by high-speed
   a. atoms b. electrons c. neutrons d. protons

5. The target of the x-ray tube is composed of
   a. lead b. aluminum c. copper d. tungsten

6. The efficiency of x-ray production in the x-ray tube is approximately
   a. 99% b. 100% c. 10% d. 0.2%

7. The positive electrode in an x-ray tube is the
   a. cathode b. anode c. electrode d. girode

8. The target of a stationary anode tube is embedded copper in order to
   a. give a sharper image c. dissipate heat
   b. focus the x-ray beam d. increase the number of x-rays produced

Directions: Answer the following questions.

9. List four properties of x-rays.

   a.____

   b.____

   c.____

   d.____

10. State what type of x-ray tube is shown in the drawing. ______________________
Label the numbered parts on the drawing.

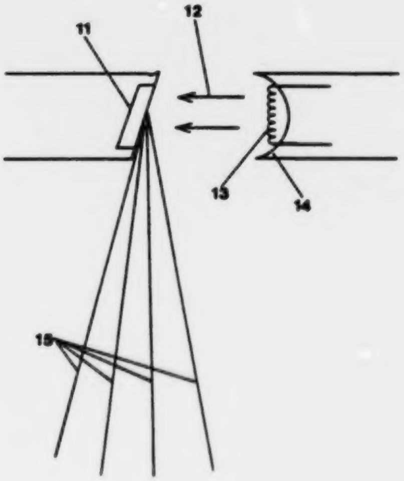
11. ______________________________

12. ______________________________

13. ______________________________

14. ______________________________

15. ______________________________

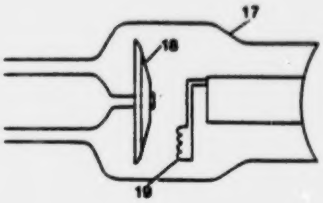


16. State what type of x-ray tube is shown in the drawing. ______________________
Label the parts on the drawing of the x-ray tube.

17. ______________________________

18. ______________________________

19. ______________________________



TEST / Unit 3

Equipment

Directions: Match by placing the letter for the definition in the blank next to the term.

____1. computerized scanner

____2. fluoroscopy

____3. gamma rays

____4. image intensifier

____5. saggital plane

____6. scintillation

____7. sonogram

____8. tomography

____9. transducer

___10. tube stand

a. plane to divide body into top and bottom sections

b. device to change energy from one form to another

c. computer used to reconstruct cross-sectional image

d. motion of tube and film blurs unwanted images

e. observation of an x-ray image on a special screen

f. brightens fluoroscopic image

g. ability to give off light

h. plane to divide body into right and left sections

i. photograph produced by ultrasound

j. invisible radiation of disintegrating radioactive materials

k. support for x-ray tube

11. Name three functions of the control panel in a radiographic unit.

12. If the patient is immobilized in bed, what type of radiographic unit must be used?

13. Which component of the radiographic unit produces high voltage necessary for the production of x-rays?

14. Explain the purpose of contrast media. Name two chemicals commonly used to produce contrast.

15. Name two differences between conventional tomography and computerized scanning.

16. Compare the gantries used in computed tomography and in magnetic resonance imaging.

17. Explain how the probe used in sonography functions as a transducer.

18. Differentiate between the uses of the gamma camera and the well counter in nuclear medicine.

TEST / Unit 4

Protection from Radiation and Infection

Directions: Circle the letter in front of the best possible answer.

1. Inheritable changes produced by exposure to radiation are called
   a. somatic effects
   b. genetic effects
   c. lethal doses
   d. roentgens

2. Occupational exposure is reported in
   a. roentgens
   b. rads
   c. rems
   d. density

3. The maximum dose of radiation permitted for persons working with ionizing radiation is
   a. rems
   b. rads
   c. MPD
   d. the absorbed dose

4. The maximum permissible dose of radiation for a radiologic technologist who is 30 years of age is
   a. 30
   b. 60
   c. 20
   d. 5

5. The determination of the accumulated radiation dosage by use of photographic film is known as the
   a. pocket dosimeter method
   b. film badge method
   c. chronic exposure method
   d. dose rate

6. Changes produced in an individual's cells and tissues exposed to radiation are called
   a. somatic effects
   b. genetic effects
   c. dosimetry
   d. rems

7. The determination of the accumulated radiation dosage by use of a small crystal that stores energy and, when radiated, releases it in the form of light is the
   a. pocket dosimeter method
   b. film badge method
   c. chronic exposure method
   d. thermoluminescent dosimeter

8. Where should the radiation monitoring device be worn?
   a. at the waist
   b. at the wrist
   c. on the collar
   d. doesn't matter where worn

9. A material used for shielding in radiology is
   a. lead
   b. aluminum
   c. plastic
   d. vinyl

10. If the radiation worker's pocket ionization chamber indicated he had received 4 rems at a distance of 6 feet from the source of radiation, how many rems would he have received if he were 12 feet from the source?
    a. 2
    b. 1
    c. 8
    d. 16

11. A monitoring device should be worn by a radiation worker during a medical or dental x-ray examination
    a. always
    b. never
    c. sometimes
    d. doesn't matter if worn or not

12. A shield of radiation-absorbing material is known as a(an)
    a. dosimeter
    b. barrier
    c. crystal
    d. ionization chamber

13. A unit of measurement for exposure of humans to one or many types of ionizing radiation is a
    a. rad
    b. rem
    c. roentgen
    d. RBE

14. An example of a disease spread by the enteric route is
    a. common cold
    b. pneumonia
    c. hepatitis
    d. stroke

Directions: Answer the following questions.

15. The principles for radiation protection are expressed by three words. These are
    a.
    b.
    c.

16. Name one legislative act that provides for standards for medical x-ray equipment and for licensing medical personnel.

17. What two agencies have authority to regulate materials used in radiology?

18. List and describe three methods by which diseases are spread.
    a.
    b.
    c.

TEST / Unit 5

Radiology Office Records and Procedures

Directions: Give complete answers to these questions.

1. List three duties of radiographic office personnel.
   a.
   b.
   c.

2. The telephone rings in the radiology office. What should the person answering the telephone say?
   a.

   The caller states that her doctor scheduled an upper GI series for her on the following day. What instructions should she be given?
   b.

3. What problem may be encountered with the use of contrast media?

4. Name two chemicals used as contrast media.
   a. b.

5. Which radiologic examination requires a "fatfree meal" as part of the preparation?

6. What is the purpose of the following procedures?

   a. upper gastrointestinal examination

   b. lower gastrointestinal examination

   c. intravenous pyelogram

7. What instructions for preparation for a mammogram should be given to a patient?

8. Point out precautions observed before a CT scan of the head is begun.

9. Describe the process of emission scanning used in nuclear medicine.

10. Define these terms:

    a. lithotripsy

    b. echocardiology

    c. Doppler ultrasound

11. Discuss the advantages of magnetic resonance imaging.

12. How many copies of a radiologic report are prepared, and where are they placed?

TEST / Unit 6

Patient Care and Transportation

Directions: Circle the letter in front of the best answer.

1. A patient who can walk unassisted is said to be
   a. semiconscious
   b. locomotive
   c. ambulatory
   d. balanced

2. To ensure good stability of the base of support of the body, the feet should be positioned
   a. parallel and very close together
   b. a few inches apart, one a little ahead of the other
   c. a few inches apart, toes pointed in
   d. close together with toes pointed out

3. The center of gravity in the body is
   a. a point around which the body weight is centered
   b. the portion of the body in contact with the floor
   c. ambulation
   d. stability produced by equal distribution of weight

4. The force that pulls the body toward the earth is called
   a ambulation
   b. base
   c. traction
   d. gravity

5. When working with an injured patient
   a. remove clothing from the unaffected side first
   b. remove clothing from the affected side first
   c. it is not important from which side clothing is removed first
   d. you do not remove clothing at all

6. Low back strain in the hospital worker is most often caused by
   a. the carelessness of other people
   b. lifting too heavy an object or person
   c. poor body mechanics
   d. proper body mechanics

7. Once a patient has started to fall, the best method of helping is to
   a. try to hold the patient up
   b. put the patient in a wheelchair
   c. call for help
   d. attempt to break the fall and ease the patient to the floor

8. Proper body alignment, movement, and balance is known as
   a. line of gravity
   b. center of gravity
   c. body mechanics
   d. ambulation

9. The position of the body when lying face up is called
   a. supine
   b. balance
   c. prone
   d. alignment

Directions: Answer these questions.

10. List the four steps to follow when putting a patient into a wheelchair.
    a.
    b.
    c.
    d.

11. List three of the four rules for good posture.
    a.
    b.
    c.

12. When the requested x-rays are completed, explain what must be done in the process of dismissing the patient.

Directions: Circle the correct answer.

13. When moving a patient, always transfer the person across the shortest/longest distance.

14. Lock/unlock all wheels on a stretcher when moving a patient from the stretcher to the x-ray table.

15. Give the patient short, simple/long, detailed commands when you wish him or her to move.

TEST / Unit 7

Radiographic Film and the Film Holder

Directions: Circle the letter of the correct answer.

1. Modern x-ray film base is made of
   a. gelatin
   b. cellulose acetate
   c. polyester
   d. glass

2. The two major components of x-ray film are
   a. cellulose acetate and polyester
   b. base and blue dye
   c. base and emulsion
   d. emulsion and gelatin

3. The chemical composition of x-ray film emulsion is
   a. calcium tungstate crystals and phosphors
   b. silver halide crystals and gelatin
   c. base and emulsion
   d. silver bromide and blue dye

Directions: Match the definition to the word by placing a letter in the blank.

____4. periapical	a. used for locating cavities between the teeth
____5. occlusal	b. used for making copies of x-rays
____6. bitewing	c. dental film
____7. renogram	d. used for examining large dental areas
____8. dosimeter	e. used in film badges to measure radiation dosage
____9. duplicating	f. used to radiograph the kidney during surgery
____10. interproximal	

Directions: Write complete answers to these questions.

11. Name two types of film.
    a.
    b.

12. Name two materials that may be used for the front of a cassette and two for the back.

Front:__________________ ________________________

Back:___________________ ________________________

13. What is the purpose of intensifying screens, and where are they found?

.TEST / Unit 8

Intensifying Screens

Directions: Write **T** in the blank if the statement is true, and **F** if the statement is false.

_____1. Afterglow from an intensifying screen is also known as *reflectance*.

_____2. The principal advantage of rare earth screens over calcium tungstate screens is speed.

_____3. The use of intensifying screens helps reduce radiation exposure to the patient.

_____4. The layer of the intensifying screen closest to the film is the base.

_____5. If the cassette containing screens is warped, poor screen-film contact may result.

_____6. The amount of exposure needed to produce a given amount of light from an intensifying screen is known as *speed*.

Directions: Fill in the blanks.

7. In a cassette, the film is sandwiched between ____________________ intensifying screens. (Give a number.)

8. The base of a screen may be made of____________________ or ________________.

9. The____________________ layer reflects light going in the direction of the base back toward the film.

10. Calcium tungstate screens glow with a____________________ colored light.

11. The__________________________ layer protects the phosphors from damage due to handling.

12. Screens are classified by type of phosphor and______________________.

13. List three necessary characteristics a phosphor must possess to be used in radiography.
    a.

    b.

    c.

14. Explain the purpose of intensifying screens.

15. Describe a method for testing screen-film contact.

TEST / Unit 9

Radiographic Darkroom

Directions: For questions 1-9, circle the letter corresponding to the correct answer. Give short answers for questions 10-13.

1. The type of darkroom entrance most often used is a
   a. revolving door c. maze
   b. single-lock door d. interlocking door

2. A lighttight holder for film used during radiation exposure is a
   a. loading bench c. pass box
   b. film bin d. cassette

3. A color suitable for darkroom walls is
   a. ivory c. red
   b. black d. brown

4. The best material for darkroom walls and floors is
   a. linoleum c. ceramic tile
   b. wood d. marble

5. Ideal temperature and humidity conditions for the darkroom are
   a. 67°-78°F; 60% humidity c. 67°-78°F; 30% humidity
   b. 80°-85°F; 60% humidity d. 80°-85°F; 30% humidity

6. For most film used in radiography, what safelight filter is recommended?
   a. Wratten 2B c. green
   b. blue d. Wratten 6B

7. How much more is film sensitive to safelight illumination, and is it before or after exposure to radiation?
   a. eight times; after c. two times; after
   b. eight times; before d. two times; before

8. The loading bench is grounded in order to
   a. make film more visible c. minimize static
   b. minimize fog d. prevent it from chipping

9. The cabinet for transferring cassettes between radiographic room and darkroom is a
   a. loading bench c. pass box
   b. film box d. cassette

10. Name two items found on the "wet" side of the darkroom.
    a.
    b.

11. Name two items found on the "dry" side of the darkroom.
    a.
    b.

12. What is the purpose of the loading bench?

13. Name two methods of identifying a radiograph.
    a.
    b.

TEST / UNIT 10

Processing Radiographs

Directions: Below are listed sections of the automatic processor. Match each to its function by writing the letter of the function in the blank.

______1. transport system

______2. water system

______3. recirculation system

______4. replenishment

______5. dryer system

a. maintains solution level and concentration

b. circulates warm air to dry film

c. removes excess liquid by squeegee action

d. keeps fresh solution in contact with the film

e. washes film and keeps solutions at correct temperature

Directions: Circle the letter of the words which best complete the sentence.

6. The solvent used for chemicals in manual and automatic processing is
   a. potassium bromide
   b. sodium sulfide
   c. water
   d. chrome alum

7. If you were to feed a 14" x 17" film into an automatic processor incorrectly, this would lead to
   a. underreplenishment
   b. overreplenishment
   c. shrinkage
   d. regulation

8. What is the function of phenidone in automatic processing?
   a. acts as an antifogging agent
   b. acts as a reducing agent
   c. controls swelling of gelatin
   d. serves as a clearing agent

9. A silver recovery unit is connected to the
   a. fixer tank
   b. developer tank
   c. wash tank
   d. dryer

10. A silver recovery method consisting of a recovery cartridge and a circulating unit is
    a. electrolytic recovery
    b. chemical precipitation
    c. metallic replacement

Directions : Give complete answers to these questions.

11. Name two methods for processing film.
    a.
    b.

12. Cite two advantages of automatic processing over manual.
    a.
    b.

13. List the three major sections of an automatic processor.
    a.
    b.
    c.

14. From what chemical does the silver come?

15. List three advantages of silver recovery.
    a.
    b.
    c.

TEST / Unit 11

Artifacts

Directions: Match by writing the letter of the artifact in the blank next to its cause.

______1. film is bent or creased

______2. use of incorrect safelight filter

______3. excessive drying temperature or time

______4. scraping film against processing tank

______5. excessive developer concentration

______6. use of outdated films

______7. films touching in the solutions

a. brittleness

b. age fog

c. scratches

d. light fog

e. crescent marks

f. mottling

g. kiss marks

Directions: In the space, write **T** if the statement is true, and **F** if it is false.

______8. Artifacts can occur with manual or automatic processing.

______9. The prime cause of artifacts is carelessness.

______10. Streaks on the radiograph are caused by lack of acid in the fixer.

______11. Cracks or grooves in the film surface are called *reticulation.*

______12. Loose hinges on the cassette cause brown stains.

Directions: Circle the letter of the best possible answer.

13. The use of exhausted fixer can cause
    a. yellow stains
    b. brown stains
    c. reticulation
    d. static

14. Poor screen-film contact or defective screens will cause
    a. white specks
    b. light fog
    c. radiation fog
    d. fuzzy image

15. If a cassette with dirty intensifying screens is used, the radiograph will have
    a. brittleness
    b. white specks
    c. a fuzzy image
    d. light fog

16. If a box of film is unshielded by lead and left in the radiographic room during an exposure, what type of fog will the film have?
    a. radiation
    b. light
    c. chemical
    d. age

17. If a radiograph processed in an automatic processor appears as shiny or greasy, it indicates that the
    a. film has been underdeveloped
    b. dryer is dirty
    c. water in the processor was not turned on
    d. rollers are not operating properly

18. A *pi* line is caused by
    a. old chemicals
    b. fresh chemicals
    c. inadequate washing
    d. dirt in the dryer

19. If the dryer temperature is too low, the film coming out of the automatic processor will be
    a. frilled
    b. fogged
    c. streaked
    d. tacky and wet

20. Contaminated wash water in the automatic processor will result in what type of films?
    a. fogged
    b. wet
    c. gritty
    d. shiny

Answers
to
Tests

UNIT 1 / The Radiologic Technologist as a Member of the Health Care Team

1. b
2. a
3. f
4. c
5. e
6. *Confidential information* is all information concerning the patient. It must be kept in confidence. It is not discussed with the patient or other hospital personnel or released over the telephone. Questions are referred to the patient's doctor.
7. the hospital
8. nuclear medicine technology, radiation therapy, sonography, magnetic resonance imaging, computed tomography (Any three)
9. board of trustees
10. aides, orderlies, housekeepers, maintenance personnel (Any two)
11. administrator
12. assistant administrators
13. staff technologists

UNIT 2 / The Production of X-rays

1. a
2. d
3. a
4. b
5. d
6. d
7. b
8. c
9. a. have short wavelengths
   b. travel in straight lines, diverging
   c. travel at the speed of light
   d. invisible
   e. cause some substances to fluoresce
   f. electrically neutral
   g. cause biological changes
   h. produce an image on film (Any four)
10. stationary anode tube
11. target
12. electrons
13. filament
14. focusing cup
15. x-rays
16. rotating anode tube
17. glass envelope
18. rotating anode
19. filament

UNIT 3 / Equipment

1. c
2. e
3. j
4. f
5. h
6. g
7. i
8. d
9. b
10. k
11. The control panel can vary the amount of radiation, penetrating ability of the beam, and exposure time.
12 mobile or bedside
13. generator
14. to render body structures visible by contrast to surrounding tissues; barium sulfate, iodine
15. Tomography records on x-ray film and produces an image parallel to the long axis of the body. CT scanning uses a computer, produces a photograph, and the image is perpendicular to the long axis of the body. (Any two)
16. The gantry for MRI is larger and has a smaller tunnel opening for patient entry.
17. It converts electrical impulses to sound waves and gathers information from the reflected sound wave.
18. The gamma camera is used to detect the amount of gamma waves given off by an organ in a patient's body. The well counter is used to count a radioactive sample of body fluid removed from a person.

UNIT 4 / Protection from Radiation and Infection

1. b
2. c
3. c
4. b
5. b
6. a
7. d
8. c
9. a
10. b
11. a
12. b
13. b
14. c
15. (a) time, (b) distance, (c) shielding
16. Radiation Control Health and Safety Act or the Consumer-Radiation Health and Safety Act
17. Nuclear Regulatory Commission, Food and Drug Administration
18. a. indirect—use of contaminated equipment or objects
    b. direct—contact between persons
    c. enteric—transmission of disease by body wastes

UNIT 5 / Radiology Office Records and Procedures

1. a. answering the telephone
   b. scheduling appointments
   c. explaining preparation procedures
   d. record keeping (Any three)

2. a. "Radiology Department, name"
   b. nothing by mouth after midnight
3. allergic response
4. a. barium sulfate
   b. iodine
5. gallbladder examination
6. a. examine the stomach, esophagus, small intestine
   b. examine the colon
   c. examine the urinary system
7. none
8. removal of jewelry, glass, and hair ornaments; patient cautioned to remain as still as possible
9. The patient is given radioactive material. It travels through the body and concentrates in an organ. The radioisotope gives off gamma rays which are recorded by a gamma camera with a scintillation crystal.
10. a. breaking up kidney stones with high-frequency ultrasound
    b. imaging how the heart valves and muscles are working
    c. measuring blood flowing through arteries and veins
11. images more body planes, less time required, no radiation
12. four; one with the radiograph, one into file, one to hospital chart, one to the patient's doctor

UNIT 6 / Patient Care and Transportation

1. c
2. b
3. a
4. d
5. a
6. c
7. d
8. c
9. a
10. a. Place chair facing patient and close to patient.
    b. Raise foot supports and lock wheels.
    c. Stand in front of patient.
    d. Support patient at sides, pivot with patient, and seat in chair.
11. a. Stand with feet parallel, at right angles to lower legs, and from 4 to 8 inches apart.
    b. Keep knees slightly bent.
    c. Keep buttocks in and abdomen up and in.
    d. The head should be held erect. (Any three).
12. Ask patient to wait until the radiologist can verify that all needed films have been obtained. Then tell patient to dress, and assist patient if needed. Return all personal property. Check records for completeness. Dismiss.
13. shortest
14. lock
15. short, simple

UNIT 7 / Radiographic Film and the Film Holder

1. c
2. c
3. b
4. c
5. d
6. a
7. f
8. e
9. b
10. a
11. a. screen film
    b. nonscreen film or direct exposure film
12. front—metal or plastic, back—aluminum or stainless steel
13. to convert x-ray energy into visible light; found on front and back covers of cassettes

UNIT 8 / Intensifying Screens

1. F
2. T
3. T
4. F
5. T
6. T
7. two
8. cardboard, polyester
9. reflective
10. blue-violet
11. protective
12. speed
13. a. The phosphor should give off a large amount of light.
    b. Light must be of proper color to match the sensitivity of the film.
    c. Phosphor should have little or no afterglow.
14. to convert x-ray energy into visible light
15. Place a wire mesh on top of a loaded cassette. Make an exposure, and process it. If the image is sharp and welldefined, contact is good.

UNIT 9 / Radiographic Darkroom

1. b
2. d
3. a
4. c
5. a
6. d
7. a
8. c
9. c
10. a. manual processing tank
    b. automatic processor
    c. sink (Any two)
11. a. film bin
    b. pass box
    c. loading bench (Any two)
12. loading and unloading cassettes

13. a. exposing an identifying number on the film at the same time as the exposure is made on the patient
    b. information on the typed identification card is exposed with the film to a small source of white light in the identification unit
    c. patient information is typed on radiopaque tape and attached to casette before exposure (Any two)

UNIT 10 / Processing Radiographs

1. c
2. f
3. d
4. a
5. b
6. c
7. a
8. b
9. a
10. c
11. a. manual
    b. automatic
12. a. shortens processing time
    b. improves quality
    c. increases work capacity (Any two)
13. a. feeding section
    b. processing section
    c. dryer
14. silver halide
15. a. conservation of silver
    b. increased profits
    c. prolonging life of fixer

UNIT 11 / Artifacts

1. e
2. d
3. a
4. c
5. f
6. b
7. g
8. T
9. T
10. F
11. T
12. F
13. a
14. d
15. b
16. a
17. c
18. b
19. d
20. c

For More Advanced Study

Below are suggestions for additional assignments for each unit in *Assisting in Radiology/Imaging*.

UNIT 1 / The Radiologic Technologist as a Member of the Health Care Team

Make a chart comparing the advantages and disadvantages of being a worker in each of the technologies mentioned in the unit.

UNIT 2 / The Production of X-rays

Explain what a wavelength is and the relationship between its speed and frequency. Look up the wavelengths of visible light, gamma rays and x-ray radiation. Record these in either ascending or descending order. These values may be found in a physical science text or in a *Handbook of Chemistry and Physics*.

Write a paper explaining the effect of milliamperage, distance, and kilovoltage on the radiographic image.

UNIT 3 / Equipment

Make a list of each major unit of equipment in the radiology department. Be sure to include all technologies, such as sonography. List the manufacturer's name and the approximate cost of each unit.

UNIT 4 / Protection from Radiation and Infection

Over a specific time period (e.g., one week, two weeks) record safety violations which you observe in the radiology department. Finally, evaluate these, and devise methods to improve safety.

Obtain a copy of either the Radiation Control for Health and Safety Act or the Consumer-Radiation Health and Safety Act. Review the Act, and prepare a short summary of it.

Research the effects of radiation exposure and the effects it has on various organs of the body. Describe radiation dermatitis. Evaluate the effects of an overdose on a radiographic technologist and of a massive overdose on a worker in an atomic plant. Develop a report. This may be oral or written in outline or essay form as determined by agreement between student and instructor.

UNIT 5 / Radiology Office Records and Procedures

Develop a flowchart to show the path a request for an x-ray must follow through the radiology department until the x-ray is completed and filed.

Select ten techniques used in radiography or imaging other than the procedures discussed in this unit. List these. Write a paragraph about each, telling how and for what it is used.

UNIT 6 / Patient Care and Transportation

Obtain both the fire plan and the disaster plan for the radiology department. Write a summary of the responsibilities of radiology personnel for reporting and evacuation when a fire is discovered. Give the location of fire extinguishers and their type. Locate exits and fire doors. Prepare a second summary to specify the role of the radiology department in dealing with a disaster. Indicate where triage and the morgue will be located. Explain how patients will move through the radiology department. Outline procedures used for a bomb threat or for a dangerous person loose in the facility.

Devise a list of fifteen safety rules for use in your radiology department dealing with both patient and worker safety.

UNIT 7 / Radiographic Film and the Film Holder

Make a series of drawings to show—
  a. cross section of film,
  b. cross section of film in a holder, and
  c. how to load a cassette.
The drawings in the book may be used for reference but may not be traced. Below or beside the drawing of film, the composition of the layers should be shown.

UNIT 8 / Intensifying Screens

Research the effect of the thickness and crystal size of the phosphor on intensification and image sharpness. Compare the effect of the three screen speeds on intensification. Tell how the crystals act to intensify.

UNIT 9 / Radiographic Darkroom

List the major pieces of equipment found in the darkroom where you work. Determine the approximate cost of each and who the manufacturer was. The cost of built-in items, such as a pass box, can be estimated. Prepare this information as a chart.

UNIT 10 / Processing Radiographs

Prepare a diagram using figure 3, *Sections of an Automatic Processor,* as a basis, and add the names of the chemical solutions used in each phase of automatic processing in the facility where you work. Show the temperature required in each phase.

Prepare an oral report for presentation to your class describing how film is developed at the place where you work. You may use actual films or drawings of film. Arrangements must be made with your instructor for this presentation.

UNIT 11 / Artifacts

Make a series of ten drawings to illustrate ten artifacts that you have seen. Explain what caused each artifact.

Develop a chart for use with automatic processing to show the causes of the artifacts that might occur.

Suggestions for Answers
to
"For More Advanced Study"

UNIT 1 / The Radiologic Technologist as a Member of the Health Care Team

The student should include comments concerning the length of time for training, the advantages that radiologic technologists have for moving into other fields, and the risks of radiation and handling radioactive substances as opposed to other technologies.

UNIT 2 / The Production of X-rays

Wavelength is the distance in the line of advance of a wave from one point to the next point. The discussion below figure 1 should be included and may be expanded. The actual wavelengths should be listed in Angstroms for the various colors of light in the visible spectrum, gamma rays, and x-radiation.

The following points should be included in the paper. Brightness increases with increased radiation. Changing the distances from the tube changes the intensity of the image. Kilovoltage changes affect the penetrating power of the x-rays and reduces subject contrast. Changing milliamperage and distance to control intensity does not affect subject contrast. However, changing kilovoltage to control intensity causes changes in subject contrast

UNIT 3 / Equipment

Major items should be listed, not small pieces of equipment. The name of the manufacturer should be exact, but cost can be approximate.

UNIT 4 / Protection from Radiation and Infection

The time period should be set by the student in consultation with the instructor. Methods of improvement should be evaluated in regard to the breaches in safety and asepsis.

Content and length of the review should be determined by the student in consultation with the instructor.

The report on radiation exposure should include the effects on the hair, nails, skin, blood, and reproductive organs. The higher incidence of various forms of cancer should be addressed. The genetic effect and its bearing on future generations should be mentioned.

UNIT 5 / Radiology Office Records and Procedures

The flowchart should be presented as a diagram, showing entry of the request with the patient, checking for previous radiographs, travel through the department, the reporting process, and final filing.

Selection of the ten studies should be made by the student with the approval of the teacher. Each paragraph should name the technique, give its modality, and explain how and for what it is used.

UNIT 6 / Patient Care and Transportation

The role of personnel will vary somewhat with the facility. However, the student should include methods for reporting fires; containment; location of fire extinguishers, fire doors, and exits; and the evacuation of patients. The disaster plan should describe the location of triage, how patients will move through radiology, and the location of the morgue. Internal problem situations will include the codes to be called.

Rules will vary. They need not be equally divided between patient and worker but should deal with both.

UNIT 7 / Radiographic Film and the Film Holder

Students' drawings should resemble figures 1, 2, and 3 in Unit 7. Drawings may be in color to differentiate layers. The cross-sectional drawing of film must have the composition of the layers shown somewhere on it.

UNIT 8 / Intensifying Screens

The thicker the layer and the larger the size of the crystal, the more intense the light, but sharpness is decreased because the light spreads. Slow screens have more sharpness, while fast screens have more intensification. Medium-speed screens provide a balance. Each phosphor crystal absorbs x-ray energy and emits light.

UNIT 9 / Radiographic Darkroom

A chart should be prepared with columns listing equipment, cost, and manufacturer. Cost should be estimated since some items, such as pass boxes, were built into the room.

UNIT 10 / Processing Radiographs

The diagram will be similar to figure 3 and have added the chemicals listed in Table 1. Temperatures should be those shown in figure 2, *Comparison of Manual and Automatic Processing Times and Temperatures.*

Presentations will vary but should include phases and chemicals similar to those outlined in the unit.

UNIT 11 / Artifacts

Drawing size and content will vary. Color may be used where appropriate.

The chart should list the artifact in one column and all factors that may cause it in another column.

COMPETENCY CHART
for
Nursing Assistant, Radiology

Directions: Evaluate the trainee, using the rating scale below. Place a check in the appropriate square to indicate degree of skill

Rating Scale:
- 4 **Skilled**—can work independently with no supervision
- 3 **Moderately skilled**—can perform job completely with limited supervision
- 2 **Limited skill**—requires instruction and close supervision
- 1 **No exposure**—no experience or knowledge in this area

		4	3	2	1
(1)	Transport patients to treatment units by	☐	☐	☐	☐
	wheelchair	☐	☐	☐	☐
	stretcher	☐	☐	☐	☐
	ambulation	☐	☐	☐	☐
(2)	Assist with robing patients	☐	☐	☐	☐
	Assist with disrobing patients	☐	☐	☐	☐
(3)	Change linen	☐	☐	☐	☐
	Clean room	☐	☐	☐	☐
(4)	Record pertinent information in the patient's chart	☐	☐	☐	☐
(5)	Adjust inventory	☐	☐	☐	☐
	Adjust supplies	☐	☐	☐	☐
(6)	Maintain inventory and supplies	☐	☐	☐	☐
(7)	Prepare and maintain work area	☐	☐	☐	☐
	procedure room	☐	☐	☐	☐
	darkroom	☐	☐	☐	☐
	office area	☐	☐	☐	☐
(8)	Distribute radiograph reports to appropriate	☐	☐	☐	☐
	unit for placement on chart	☐	☐	☐	☐
	radiology department file	☐	☐	☐	☐
	hospital unit	☐	☐	☐	☐
(9)	Assist in record keeping				
	Be familiar with—	☐	☐	☐	☐
	request form	☐	☐	☐	☐
	filing system	☐	☐	☐	☐
	billing system	☐	☐	☐	☐

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TX92CD04

ASSISTING IN RADIOLOGY / IMAGING

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Assisting in Radiology/Imaging

Student's Manual

By

Helena J. Fair

Published by

The University of Texas at Austin
Educational Resources
Extension Instruction and Materials Center
Division of Continuing Education

1992

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Printed in the United States of America

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Editor / Barbara Sutherland
Artist / Elinor Gamache
Publishing Technician / Kathryn N. Roberts
Production Coordinator / Barbara Sutherland
Director, Educational Resources / Barbara E. Selke-Kern, Ph.D.

Additional copies may be ordered from:

THE UNIVERSITY OF TEXAS AT AUSTIN
Educational Resources
Extension Instruction and Materials Center
P.O. Box 7218
Austin, TX 78713-7218
512-471-7716 or 1-800-252-3461 (within Texas)
FAX 512-471-7853

Stock Number HO 220 S

Contents

Notes for the Student iv

Acknowledgments v

Unit 1 / The Radiologic Technologist as a Member of the Health Care Team 1

Unit 2 / The Production of X-rays 6

Unit 3 / Equipment 10

Unit 4 / Protection from Radiation and Infection 15

Unit 5 / Radiology Office Records and Procedures 20

Unit 6 / Patient Care and Transportation 28

Unit 7 / Radiographic Film and the Film Holder 33

Unit 8 / Intensifying Screens 37

Unit 9 / Radiographic Darkroom 40

Unit 10 / Processing Radiographs 44

Unit 11 / Artifacts 51

Glossary of Radiographic Terms 55

Bibliography 57

Notes for the Student

Assisting in Radiology/Imaging is designed for use by students investigating the activities within the radiology department or considering any of the imaging technologies as a career. The material is designed to relate training experience to information studied in the classroom. Information is provided which is current and relevant to the essential elements approved by the Texas State Board of Education, 1988. The material is designed for individualized study and is competency-based with objectives or outcomes stated for each unit. *Assisting in Radiology/Imaging* is made up of three separate publications.

- The **Student's Manual** contains learning objectives, terms and definitions, and information relating to current techniques and technologies. Clinical use of radiation, procedures for film loading and development, and types of equipment are presented. Both radiation and biological safety are emphasized. New imaging technologies, such as ultrasound and magnetic resonance, are introduced.

- The **Student Learning Activities** are individualized and designed to encourage the student to carefully read and study the information presented. Instructors are encouraged to provide one set for each student to facilitate learning.

- The **Instructor's Guide** provides a list of essential elements correlated to the units of instruction. A basic test is provided for each unit. Instructors are encouraged to enlarge these. Answers to tests and learning activities are included. A section has been added for those students desiring a more advanced study of each unit. A competency chart is included.

Acknowledgments

The Extension Instruction and Materials Center wishes to acknowledge with grateful appreciation the cooperation and assistance of the following health occupations teachers and professionals who served as members of the 1991-92 Health Occupations Project Advisory Committee:

- Jeanne Ballard, Education Coordinator for the Medical Laboratory, Seton Hospital, Austin, Texas
- Gail Beard, former HOE Educator, Houston, Texas
- Pam Buchanan, Lecturer for Kinesiology and Health, The University of Texas at Austin
- Fran Donohue, Health Occupations Educator, Victoria High School, Victoria, Texas
- Brenda Luckie, Coordinator for Ancillary Services, Student Health Center, The University of Texas at Austin
- Linda Montgomery, Health Occupations Educator, Brenham High School, Brenham, Texas
- Ann O'Sullivan, Radiology Technologist, Capital Radiology, Austin, Texas
- Carolyn Ragland, Instructor, Austin Community College, Riverside Campus, Health Sciences/Medical Laboratory Technology, Austin, Texas
- Judy Rose, Health Occupations Educator, Stephen F. Austin High School, Austin, Texas
- Barbara Selke-Kern, Director, Educational Resources, EIMC, The University of Texas at Austin
- Spanky Stephens, Head Athletic Trainer, Men's Intercollegiate Athletics, The University of Texas at Austin

Special thanks go to the Radiology Department, Memorial Medical Center of East Texas, Lufkin, Texas, for suggestions to update Table 1, "Preparations for Radiographic Examinations"; to Bev Brack, Radiologic Technologist, Blinn College, Brenham, Texas, for her comments on film size and chart forms; and to Charlotte Rutherford, R.T., Houston, Texas, for information included in the Glossary of Radiographic Terms.

The Center also recognizes with gratitude the support and suggestions provided by Barbara Terrell, State Program Director for Secondary Health Occupations Education, Texas Education Agency, Austin.

Portions of this book are adapted from Extension Instruction and Materials Center's 1984 publication, *Assisting in Radiology,* written by Janet Schnauze.

1

The Radiologic Technologist as a Member of the Health Care Team

---

Objectives: After completing this unit, you will be able to—

1. *discuss responsibilities for confidentiality associated with patient information;*
2. *describe the importance of the radiologic technologist as a member of the health care team;*
3. *diagram an organizational chart for a radiology department;*
4. *diagram an organizational chart for a hospital;*
5. *identify educational requirements and responsibilities of radiology/imaging department personnel; and*
6. *explain the use of radiology in dentistry.*

Terms and Definitions

computed tomography (CT)—a way of visualizing different parts of the body in the axial plane using an x-ray tube, a special x-ray device, and a computer.

confidential (privileged) communication—all information concerning the patient; not to be discussed or given out.

magnetic resonance imaging (MRI)—use of the magnetic properties of ions to create diagnostic images of internal body structures.

nuclear medicine—that branch of medicine which uses radioactive substances to diagnose and treat patients.

radiation—process of emitting energy in the forms of waves or particles.

radioisotope—radioactive material used to diagnose and treat disease.

radiologic technologist (radiographer)—allied health professional who produces diagnostic radiographs.

radiologist—a physician specializing in the use of radiation for diagnosis or treatment.

ultrasound—vibrations of the same physical nature as sound, but with frequencies above the range of human hearing; sound wave energy of extremely high frequency that may be used in diagnosis or limited therapeutic applications.

sonographer—allied health professional who uses sound waves and their echoes to record internal body structures.

The field of modern medicine is a complicated organization composed of precision teams, including various paramedical professions, all working for one common goal. This is to preserve, maintain, or restore the health of human beings. Radiologic technology is one small, important team that plays a very essential part in the practice of the art and science of medicine. Individuals in medical or paramedical careers must possess one basic, essential characteristic. They must sincerely desire to help other people, and they must want to devote their knowledge, time, and efforts to this end.

The word *hospital* is derived from the French word *hospes*, meaning guest. Every person concerned with patient care interprets the hospital to patients and has the responsibility of serving as host or hostess. It is important to receive and care for the patient as a guest, with the graciousness of a considerate host.

The hospital is a combination of various components, each working interdependently with the others. Its purpose is to improve upon or restore the health of all who enter for help.

Confidential Communication

Most patients are worried individuals. Naturally, they are curious and seek information about themselves and the results of their examinations. Therefore, they tend to be much more sensitive to hearing conversation. Technologists must avoid any nonpertinent conversations within hearing of the patients. These conversations might well involve something entirely foreign to the situation, leaving patients with a lonely, lost feeling. Patients' whole concept of the hospital may be colored by the technologist's graciousness or lack of it.

In the hospital, most patients feel they are at quite a disadvantage. They must reveal many personal facts and wonder if these will be kept inside the hospital and protected. This personal information will be given reluctantly unless the patients feel secure and confident in the persons who care for them.

It is the responsibility of the health care team to keep all information about the patient strictly confidential. The code of ethics of a radiologic technologist is based upon one fundamental point. This is the fact that any information obtained by the technologist in the course of his or her work is confidential. The information does not belong to the technologist, and under no circumstances should the technologist ever disclose any information about the patient.

Privileged or confidential communication includes all the information pertinent to the patient's care. Information that is found in the patient's hospital record as a result of the direct relationship of patient and doctor is part of this confidential communication. The hospital is both legally and ethically obliged to protect this information from curious individuals who have no right to this knowledge. No professional information is ever released over the telephone. Confidences entrusted to a radiologic technologist by the patient carry professional as well as legal responsibilities. The technologist's status as a member of the professional team requires these matters to be kept in confidence.

When a patient asks a technologist about the results of an x-ray examination, the patient should be told, very tactfully, that the doctor will give the results. The facts about the patient derived from the interpretation of x-ray films, and from any other source, is within the confidential physician-patient relationship. The patient has a right to the full use of this information, including the right to insist that it be transmitted to the physician of his or her choice. But it is the duty of the attending physician, and not the technologist, to relay such information.

The rule of confidential communication does not imply that a patient owns these films. Radiographs taken in the hospital are the property of the hospital. The hospital is an institution in which a radiologist can carry out the work of the specialized field, that of medical consultant. Findings and treatments become a part of the hospital record in much the same way as clinical records. The patient pays for knowledge and experience. Radiographs are taken for the purpose of medical diagnosis and professional advice. However, radiographs may be "checked out" when seeing another doctor.

Organization of the Hospital

Hospitals are governed by a board of trustees that establishes policies and goals. Directly responsible to the board is the hospital administrator or director. He or she must see that suitable equipment and well-trained personnel are provided for patient care. The administrator may be assisted by several assistant administrators who are responsible for one or more departments within the hospital In turn, each department has a supervisor with expertise in the area of responsibility. Each department supervisor manages a group of employees who carry out the goals and objectives of the department. Figure 1 is an example of a hospital organizational chart.

The Health Care Team

For effectiveness and efficiency, health workers are grouped into a team to deliver patient care. The leader of the health care team is the physician. A *physician* is a health profes-

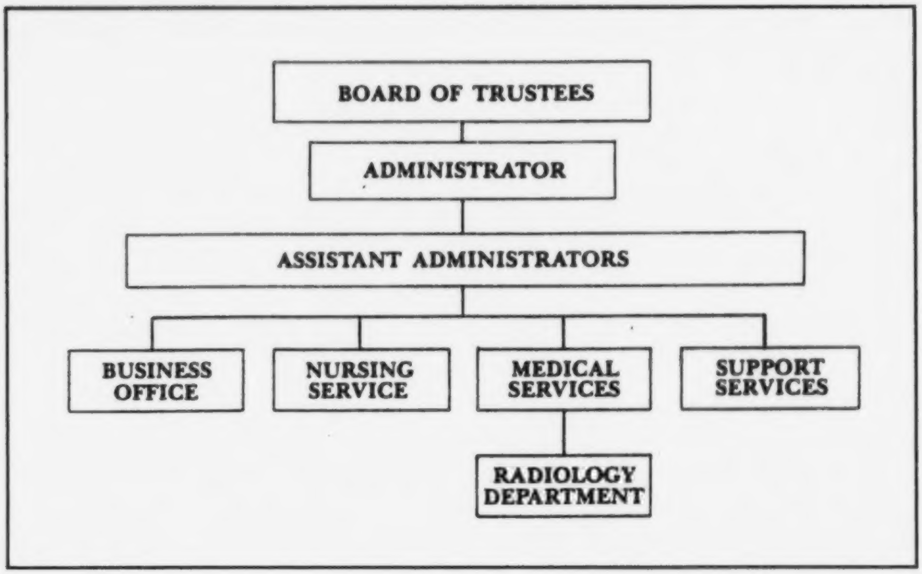


Fig. 1. Hospital organization chart

sional who performs medical examinations, diagnoses disease, and treats patients who are suffering from disease or injury.

To become a physician requires four years of college, graduation after four years in an accredited medical school, one to two years of internship, and successful completion of a licensing examination. If a doctor wishes to specialize in a particular branch of medicine, then he or she will spend an additional two to five years working in a hospital under supervision to learn a specialty. The medical specialist who uses radiant energy in diagnosis and treatment of disease is called a *radiologist*.

Other members of the health care team, led by a physician, will be nurses, all types of therapists, diagnostic workers, dietitians, social workers, pharmacists, and those who keep records in the business office and record room. Support services, such as housekeeping and maintenance, are important in keeping a facility functioning efficiently.

The members of the health care team will vary according to the patient's needs and the type of facility providing the care. Under the team approach to patient care, one individual does not have to be an expert at everything. Each member of the team provides the very best of her/his specialty area. Team meetings are held on a regular basis to coordinate all the treatments and to discuss the patient's progress.

Organization of the Radiology Department

The radiology department is an important and busy area of the hospital. Physicians refer patients to radiology for help in diagnosing a patient's illness.

Radiologists are physicians who specialize in the use of x-rays and other types of radiation in diagnosing and treating disease. The *chief radiologist* is the director of the department and is responsible for its functioning as an efficient, organized unit. Radiologists establish standards of care within the department and perform examinations with the assistance of radiologic technologists. In the radiology department, an *administrative or chief technologist* supervises the staff technologists and other personnel. In addition, the chief technologist works with the radiologist to develop department policies and budgets. A relatively new position in most large radiology departments is the *radiology department administrator*. This administrative person is directly under the chief radiologist and is responsible for the overall operation of the department.

The staff technologists or radiographers perform the radiographic examinations on the patients and assist the radiologists. Student technologists may be part of radiology departments affiliated with educational programs in radiologic technology. Usually, one technologist in the department is designated a student coordinator or clinical instructor.

An important part of any department is the clerical and support personnel. Clerical personnel keep accurate records and prepare and distribute reports of radiographic examinations. Support personnel members include aides, orderlies, and housekeeping and maintenance staff. Without these services, the department would not function efficiently. See figure 2 for a sample organizational chart of a radiology department.

No matter what position a person holds in the hospital or departmental organizational structure, all members are working together for the welfare of the most important person in the hospital—the patient.

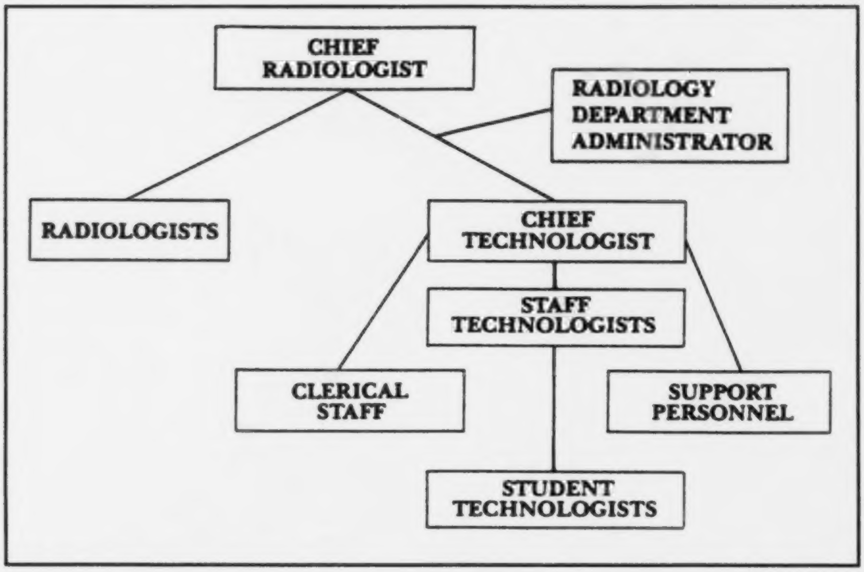


Fig. 2. Organization of the radiology department

Radiologic and Imaging Technologies

Radiologic technology encompasses four specialties and two emerging fields. The specialties are (1) radiography, (2) nuclear medicine technology, (3) radiation therapy, and (4) sonography. The emerging technologies, which exist as extensions of radiography at present, are magnetic resonance imaging and computed tomography.

The *radiographer* or *radiologic technologist (R.T.)* is concerned with proper operation of x-ray equipment and preparation of patients for various types of diagnostic procedures. It is the radiographer's duty to produce diagnostic radiographs for the radiologist. Educational programs are of three types, requiring a minimum of two years of training. Certificate programs are offered in hospitals in some states. Other states require associate degree programs in a community college or a four-year bachelor's degree program in colleges or universities. After training is completed, the candidate must pass the test given by the American Registry of Radiologic Technologists to be a certified Radiologic Technologist (American Registry of Radiologic Technologists), or R.T. (A.R.R.T.)

Many technologists advance into the other fields of magnetic resonance imaging or computed tomography through on-the-job training, courses in special schools, and classes offered by equipment manufacturers.

The *nuclear medicine technologist (N.M.T.)* performs examinations that require the administration of short-lived radioactive substances. The technologist operates equipment that detects the distribution of the radioactivity in the patient's body or the organ under study. Under the physician's guidance, the technologist makes dose calculations and is responsible for safe storage and disposal of radioactive materials used in this discipline. Educational programs are of three types: (1) one-year certificate programs for persons already registered in radiography; (2) two-year associate degree programs; and (3) four-year bachelor's degree programs. Certification is voluntary and may be obtained through the Nuclear Medicine Technology Certification Board, the Board of Registry of the American Society of Clinical Pathologists, and the American Registry of Radiologic Technologists.

The *radiation therapy technologist* assists the radiologist in administering various types of radiation to treat the patient's illness, usually a malignant disease. If an individual has a background in a health field, he or she may study one year to become a radiation therapy technologist. Two years is required for a person with no previous health-related training. Graduates of programs in allied health specialties are required to pass some type of certification examination.

Diagnostic medical sonographers or *ultrasound technicians* prepare patients for procedures, maintain equipment, and keep records. The technician must produce a quality visual image for interpretation by a physician. The sound wave must locate and record disease and injury accurately and without risk to patient or technologist. Training varies but usually lasts twelve months if the person has experience in another allied health discipline or two years of prerequisite college courses. Some schools offer a two-year training program, while others have programs leading to a baccalaureate degree. A national examination is given by the American Registry of Diagnostic Sonography to ensure and register technical competence. Technicians may advance into specialty areas, such as echoencephalogy (the brain), echocardiology (the heart), ophthalmic ultrasound (eyes), abdominal ultrasound, and Doppler technology (the examination of blood vessels).

Radiology and Dentistry

Dentistry is another health field in which radiology plays an important part. A dentist can visually examine most of the surfaces of teeth. Conditions such as root abscesses or caries between the teeth, however, can only be detected by radiographs. Radiographs are one of the best diagnostic methods available to the dentist. Dental assistants must acquire techniques to produce radiographs of good quality while at the same time showing proper concern for the safety of the patient. A dental assistant must pass an examination soon after employment before being allowed to expose and develop dental radiographs under the supervision of a dentist. Dental hygienists are also permitted to prepare dental x-rays.

Summary

The importance of radiology department personnel as members of the health team is presented. Confidentiality of patient records is stressed. Educational requirements and responsibilities of various levels of personnel are described. The use of radiographs, as a diagnostic tool for dentistry, is noted.

2

The Production of X-rays

Objectives: After completing this unit, you will be able to—

1. *list four properties of x-rays.*
2. *state the speed at which x-rays travel;*
3. *name the three major parts of an x-ray tube;*
4. *label the parts on a drawing of an x-ray tube; and*
5. *state the purpose of the generator controls.*

Terms and Definitions

anode—component of an x-ray tube; block of copper containing the tungsten target; positive terminal.

cathode—component of an x-ray tube containing the tungsten filament that is heated to produce electrons; negative terminal.

divergent—drawing apart from a common point.

electron—particle of negative electricity.

fluorescence—ability of certain crystals to emit light when struck by x-ray or other radiations.

focal film distance (FFD)—the distance from the point of origin of the x-rays to the film.

focal point—the area of the target struck by electrons from the heated filament.

generator—a device that converts mechanical energy into electrical energy.

radiograph—photograph produced on a special film by the passage of x-rays through an object or a body.

source-to-image receptor distance (SID)—the distance from the point of origin of the x-rays to the image receptor.

target—tungsten block or disc in an x-ray tube in which x-rays are produced.

wavelength—the distance in the line of advance of a waveform from one point to the next point.

Abbreviations

KV—kilovolt or unit of potential difference which is 1,000 volts.

KVP—kilovolt peak.

MA—milliampere or one-thousandth of an ampere.

In November 1895, a German physicist, Wilhelm Konrad Roentgen, was operating a type of tube called a Crooks' tube at high voltage when he noticed a glow coming from cardboard coated with barium platinocyanide crystals, several feet away from the tube. He realized that this glow or fluorescence was caused by the invisible radiation leaving the tube. He named this new type of radiation *x-rays* because, in mathematics, *X* represents the unknown.

The Nature of X-rays

X-rays are a form of electromagnetic radiation. Imagine a person throwing a stone into a lake. The water moves in all directions away from the stone. Radiation moves away from the source in a wavelike motion similar to the movement of the water. X-rays are the same type of radiation as radio waves, visible light, or television, except that x-rays have a much shorter wavelength (see fig. 1). For example, the wavelengths used in television are approximately equal to the height of an average man, while medical x-rays have an average wavelength of about one-billionth of an inch.

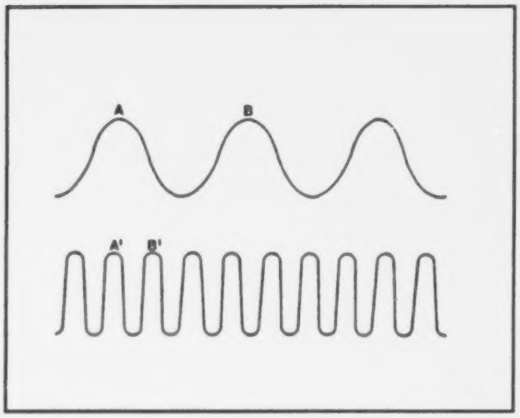


Figure 1. Electromagnetic waves. The upper and lower waves differ in wavelength; that is, the distance between two crests such as A to B and A' to B'. The lower wave thus has a shorter wavelength and, therefore, more crests in a given period of time than does the upper wave because their speeds are identical. Thus, the wave with the shorter wavelength vibrates faster, which means it has greater frequency.

Because x-rays have such short wavelengths, they can penetrate materials that would absorb or reflect other types of electromagnetic radiation such as visible light. When x-rays are produced, they leave the source of their production in a divergent manner. They travel in straight lines at an extremely fast speed, 186,000 miles per second, the speed of light. Although they are invisible, they can cause certain substances to fluoresce, or glow. They produce an image on a film that can be made visible by processing. X-rays are electrically neutral. In other words, they are neither positive nor negative.

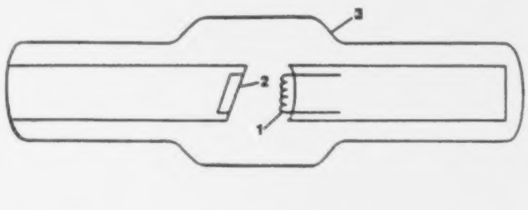
X-rays can cause certain biologic changes in humans, which necessitates caution in working with x-radiation. It is this same property that allows x-radiation to be used in treating patients.

X-rays are produced whenever fast-moving electrons strike a target. An electron is a tiny particle that bears a negative charge. The electrons are made available by heating a coil of tungsten wire, called a filament, similar to the wire in a light bulb. By applying a high voltage (kilovoltage) or potential difference, the electrons are accelerated toward the positively charged target, the anode. (A rule of physics is that *like charges repel and unlike charges attract.*) The target is made of a block, or disk, of tungsten, a material with a high melting point and a high atomic number. This is necessary because only a small portion of the energy in the electron beam (0.2 percent) becomes x-ray energy, while the remainder is converted to heat.

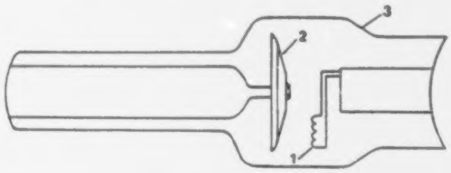
The X-ray Tube

The x-ray tube consists of three major parts: (1) the *cathode* (negative terminal), (2) the *anode* (positive terminal), and (3) the *glass envelope* (see fig. 2A).

The cathode contains a tungsten wire, called the *filament*, mounted in a holder, called the *focusing cup*. The focusing cup guides the electrons toward the target. The anode is formed from a block of copper containing a smaller block in tungsten set into the copper. The tungsten is the target on which the electrons from the filament strike and produce x-rays. Tungsten is used because of its extremely high melting point, while the block of copper helps to dissipate the heat produced. This type of tube is known as a *stationary an-*



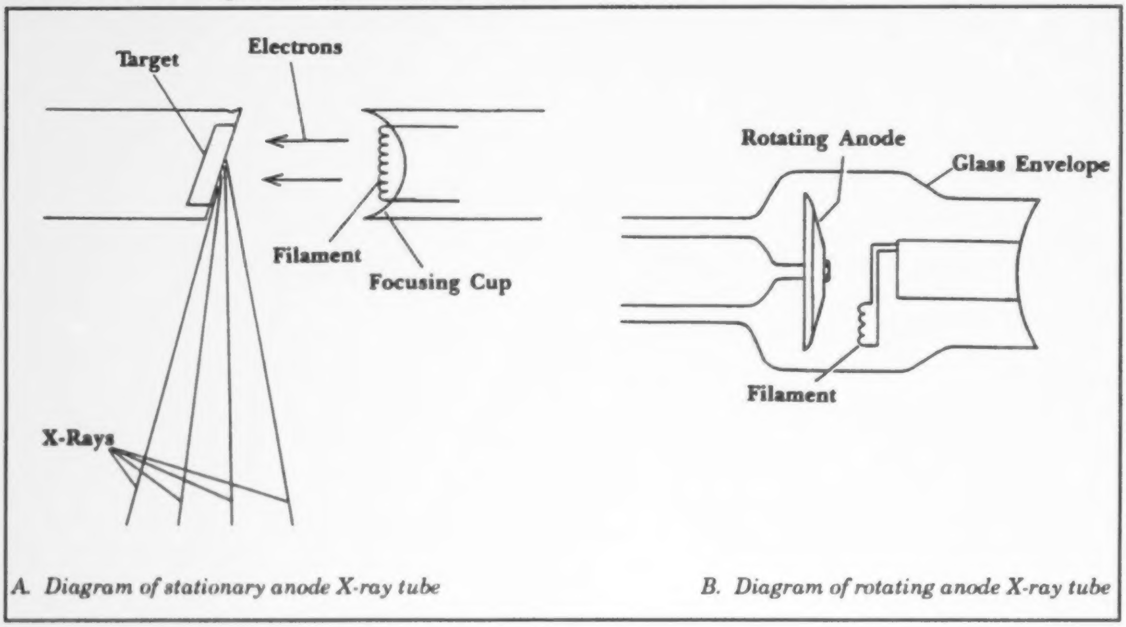
A. Stationary anode tube: (1) cathode, (2) anode, and (3) glass envelope.



B. Rotating anode tube: (1) cathode, (2) anode, and (3) glass envelope

Figure 2

Most x-ray tubes today are of the *rotating anode type* (see fig. 2B). The tungsten target is attached to the anode disk, which is mushroom-shaped. The anode disk is attached to the rotor (an induction motor that causes the anode to rotate) by a molybdenum stem. The rotor will spin when energized which, in turn, causes the anode to rotate at speeds of 3,000–10,000 revolutions per minute. The filament remains fixed and directs its electron stream to the beveled edge of the rotating disk. This rotation permits more rapid dissipation of heat than with a stationary anode tube (see fig. 3). The area of the target which the electrons strike is called the *focal spot*.



A. Diagram of stationary anode X-ray tube

B. Diagram of rotating anode X-ray tube

Figure 3

The cathode and anode are encased in a Pyrex glass envelope from which all air has been evacuated. The vacuum allows more efficient x-ray production and longer tube life. The x-ray tube is mounted inside a metal housing for protection from radiation and electrical hazards.

Generator Controls

The radiographer works with controls that determine the functioning of the x-ray tube (see fig. 4). The milliamperage selector allows the radiographer to select the amount of current to the filament of the x-ray tube. The higher the milliampere setting, the hotter the filament and the more electrons available to travel to the anode, thus producing more x-radiation. During the exposure, an MA meter on the control indicates the milliamperage produced.

Kilovoltage controls the penetrating power of the x-ray beam. By increasing the kilovoltage by means of the KV selector, the x-rays leaving the tube increase in energy and become more penetrating. The timer on the control panel determines the length of time the x-ray production takes place. After the radiographer sets the proper MA, KVP (peak kilovoltage), and time on the control and is ready to make the exposure, she or he activates the rotor, which causes the anode to spin. While holding the rotor switch down, the exposure switch is then closed, thus making the exposure. The higher the milliamperage and the longer the exposure time, the more exposure to the patient.

X-radiation, discovered by accident, has had a major impact on the field of medicine. It has been used to make a photographic record on special film as radiation passes through or fails to penetrate body structures. These pictures are called *radiographs*.

Summary

This unit explains the nature of x-rays, their production in two types of x-ray tubes, and how they are controlled by a generator.

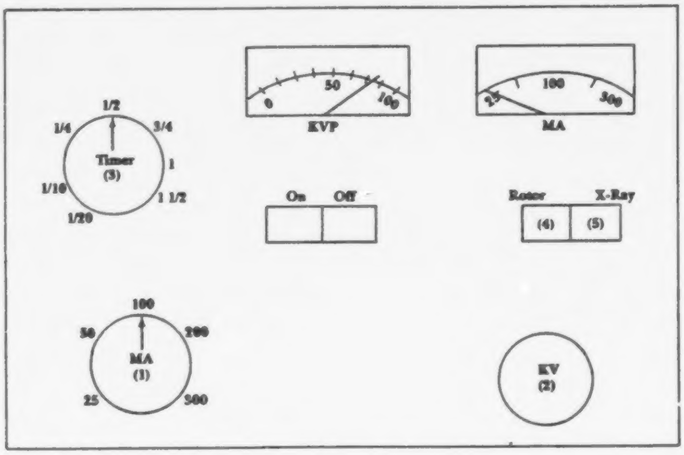

50
0
100
KVP
100
25
300
MA
1/2
1/4
3/4
Timer
(3)
1
1/10
1 1/2
1/20
On
Off
Rotor
X-Ray
(4)
(5)
100
50
200
MA
(1)
25
300
KV
(2)

Fig. 4. Example of a typical control panel of an X-ray unit: (1) milliamperage selector, (2) kilovoltage selector, (3) exposure time (in seconds), (4) rotor, and (5) exposure switch.

3

Equipment

Objectives: After completing this unit, you will be able to—

1. *name the principal components of a radiographic unit and the function of each;*
2. *describe the purpose of contrast media;*
3. *state the purpose of fluoroscopy;*
4. *name one advantage of television monitoring for fluoroscopy;*
5. *state two uses of a mobile radiographic unit;*
6. *cite a reason for using tomography;*
7. *give the function of a computerized scanner;*
8. *name the developer of the computerized scanner;*
9. *compare the MRI gantry to the CT scanner gantry;*
10. *explain the purpose of the transducer in sonography; and*
11. *describe how scintillation is used to produce an image using radioactive substances.*

Terms and Definitions

axial plane (transverse plane)—the imaginary plane that divides the body into top and bottom halves.

barium sulfate—radiopaque chemical compound used to visualize body structures in radiologic studies.

contrast media—substances administered to render body structures visible by contrast in the density of the structure and its surrounding tissues.

fluoroscopy—observation of an x-ray image on a fluorescent screen.

frontal or coronal plane—the imaginary plane that divides the body into anterior and posterior portions.

gamma rays—invisible radiation; rays given off during the disintegration of some radioactive elements.

gantry—a structure that houses components used in imaging for computed tomography or magnetic resonance imaging, and also supports a patient moved in on a table.

hertz (Hz)—unit of measurement of wave frequency equal to one cycle per second (cps).

image intensifier—complex electronic device that increases the brightness of the image.

longitudinal—placed or running lengthwise.

magnetic resonance imaging—a modality using properties of atoms within the body to create diagnostic images.

nuclear medicine—medical specialty concerned with the use of radioactive materials for diagnostic and therapeutic purposes.

remnant radiation—exit beam of radiation emerging from the body.

saggital plane—the imaginary plane that divides the body into right and left halves.

scintillation—ability to give off light.

sonogram—photographic image produced by ultrasonography.

sonography—the use of ultrasound to produce a photograph or image of a body structure.

tomography—motion of the tube and film in opposite directions during the radiographic exposure to blur unwanted structures.

transducer—a device to convert energy from one form to another; probe which changes electrical impules to ultrasound waves and gathers information from the reflected sound wave.

tube stand—support for the x-ray tube so that it can be moved freely into position over the patient.

Since x-rays were first discovered by Wilhelm Konrad Roentgen in Germany in 1895, equipment has continually improved. Today, patients have the benefit of complex, yet safe, diagnostic procedures.

Radiographic Equipment

Radiographic equipment consists of several principal components. These are the *tube stand, control panel, generator*, and *table*.

The function of the tube stand is to support the x-ray tube in such a manner that it can be moved freely into position over the patient. The tube stand may consist of a column that glides in a track on the floor. A crossarm on the vertical column supports the x-ray tube. A second type of tube stand moves between tracks on the floor and ceiling. A third type is suspended from the ceiling track. With this type, the tube can usually be moved to cover most of the x-ray room. With most tube stands, the tube can be moved longitudinally, horizontally, vertically, and rotated at various angles. The tube is counterweighted so that it can be moved easily.

Placement controls on the tube stand allow the radiographer to move the tube freely and to lock it securely when it is in the required position. It is important to release the locks before attempting to maneuver the tube into position so that damage will not occur to the locking mechanisms.

The control panel of the x-ray unit contains the equipment the radiographer uses to change the features of x-ray output. In a routine day's work, the radiographer encounters many different patient sizes and body types. Some patients require a very penetrating beam while others require a beam with less penetrating power. Adults and infants require different types and amounts of radiation and different exposure times. Control dials that vary the amount of radiation (milliamperage), penetrating ability of the beam (kilovoltage), and exposure time are found on the panel.

The generator contains complicated equipment necessary to produce the high voltage. It also has other components necessary for the production of x-radiation.

The x-ray table may be stationary, or it may tilt as much as 90 degrees in either direction. Newer tables have a four-way, power-driven top (floating top) that moves longitudinally and transversely on the base. This type of table makes positioning simpler for both the radiographer and the patient.

Contrast Media

Sometimes a body structure is difficult to visualize on radiographs because it shows little contrast to the surrounding structures. Chemicals can be taken into the body to enhance contrast. These chemicals are called *contrast media*. Some of the substances absorb more radiation and become radiopaque. Others are less absorbing and are radiotransparent.

Barium sulfate and iodine are two commonly used contrast media. Barium sulfate is used to show parts of the digestive system. Various iodine compounds are used to show parts of the urinary and respiratory systems. Radioactive forms are used in the diagnosis and treatment of thyroid disorders. Since air alters x-ray absorption and increases visualization, it can also be used as a contrast medium.

Fluoroscopic Equipment

When a patient is placed between the x-ray tube and a fluorescent screen, the x-ray image is visible on that screen. With the use of a fluoroscopic unit, the radiologist can watch the movement of various organs in the body and determine if an organ is functioning properly.

Fluoroscopic equipment varies widely among manufacturers. Most pieces of equipment contain a mechanism the radiologist uses to take radiographs, known as "spot films," in the course of a fluoroscopic examination.

In the earliest units, the front of the fluorescent screen was covered with lead glass to protect the radiologist and radiographer from radiation. Because the screen was not very bright and the sharpness of the structures seen was limited, some means of increasing the brightness was needed. Today, fluoroscopic units include an *image intensifier*. This is an electronic device that brightens the image from 1,000 to 3,000 times over conventional fluoroscopic screens.

A further advance came with the development of the television monitoring system for fluoroscopy. Television monitoring has numerous advantages. Several persons can view the image at the same time, and monitors can even be placed outside the examination room for others to observe. Remote control units allow the radiologist and radiographer to remain outside the fluoroscopic room during the examination. Instructions to the patient may be given through a speaker, and, without anyone entering the room, the table the patient lies on can be moved to place the patient in different positions.

The development of image intensification and television monitoring have greatly reduced the radiation exposure to the patient, while remote control units has reduced radiation exposure to radiology department personnel.

Bedside (Mobile) Equipment

Sometimes it is necessary to take radiographs of patients who cannot be brought to the radiology department. The patient may be too ill or may be immobilized in bed. In these cases, it is necessary to take the equipment to the patient by means of a bedside or mobile unit. Mobile units are mounted on wheels and can be pushed or pulled by the radiologic technician to the patient's room or, in some cases, to surgery.

Some of the newer mobile units are motor-driven, so it is necessary for the radiographer simply to guide the equipment into place. Mobile equipment is plugged into an electrical outlet, or it may be battery-operated.

Tomography

A radiograph is a two-dimensional image of structures in the body. Many structures are superimposed, and it becomes difficult for the radiologist to interpret the radiograph and provide a diagnosis. When this occurs, a procedure called tomography may be used. The term *tomos* is the Greek word meaning "to cut," and *graphy* means "to write." The image is called a *tomogram*. *Tomography* involves moving the x-ray tube and film, which are connected together, in opposite directions during the exposure. This motion blurs the structures that are not in focus while the area of interest appears sharp and clear.

The many uses of tomographic units range from simple to complex, but all aid the radiographer in producing a diagnostic radiograph of areas of the body that are difficult to demonstrate.

Computed Tomography (CT)

Computed tomography, as in regular tomography, also isolates the area of interest from superimposing structures. However, computed tomography, or *CT scanning*, is different in that the image is not recorded on film, as in tomography. The x-ray beam is directed at the patient, and the remnant radiation is measured by a detector whose response is transmitted to a computer. The computer analyzes the signal from the detector and reconstructs a cross-sectional image on a television monitor. Conventional tomography produces an image that is parallel to the long axis of the body, while a CT scan produces an image perpendicular to the long axis of the body (see fig. 1). The image can then be photographed and kept on file.

The CT scanner is a very large unit that requires considerable space in the radiology department. The x-ray tube and detectors are contained in a large component called the *gantry*. The table on which the patient is placed can be moved into the gantry between the x-ray tube and detectors. Other major components of the CT scanner are the operating console, which contains the controls that the radiographer operates, and the computer. Figure 2 shows these parts.

The CT scanner is a very complex radiographic unit. It was first demonstrated in 1970 by Godfrey Hounsfield, an engineer with E.M.I., Ltd., the British company that became well known for recording the Beatles. Hounsfield won the Nobel Prize for Medicine for his development of the CT scanner, which has become a valuable diagnostic tool.

Magnetic Resonance Imaging (MRI)

The MRI scanner resembles the CT scanner in many ways. Both have a gantry, but with the MRI scanner the gantry is very large with a relatively small tunnel opening for pa-

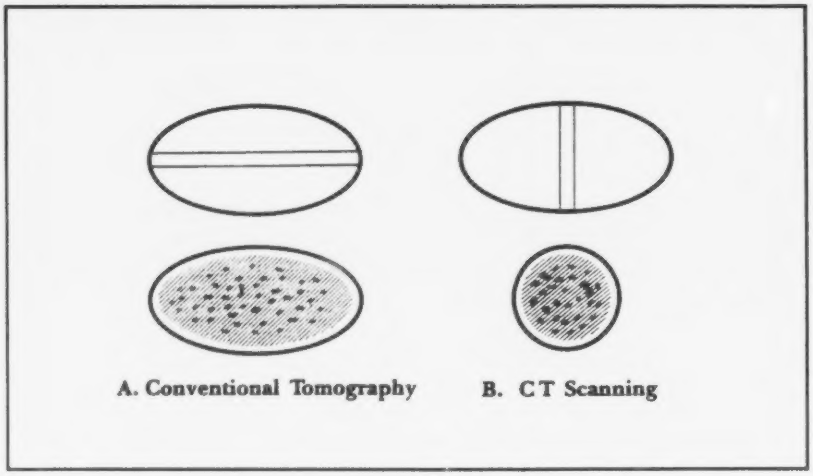


Fig. 1. Imagine cutting a watermelon lengthwise (A. conventional tomography) as opposed to cutting a piece crosswise out of the melon (B. CT scanning).

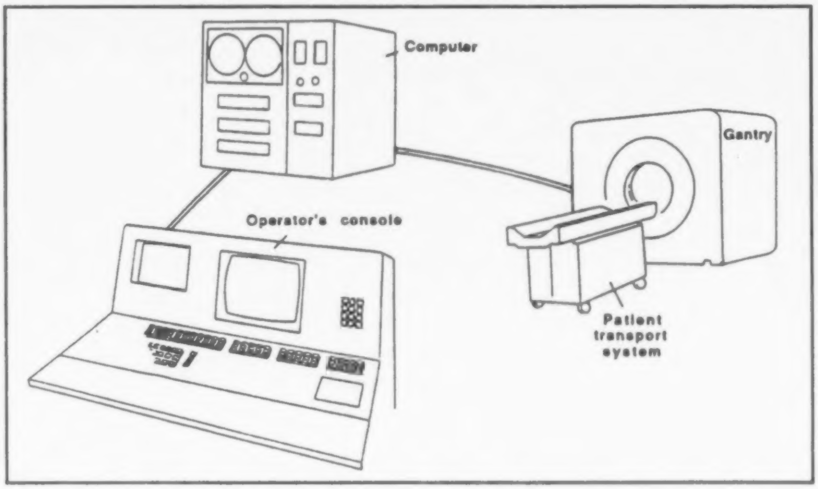


Fig. 2. Computed tomography system

tient entry. Within the gantry is a large magnet, a radio frequency transceiver, gradient coils, and other pieces of electronic equipment for transferring information to the computer and for moving the patient in and out of the machine. A computer is needed to produce images.

Different types of magnets are available depending on the needs of the facility as to budget, efficiency, and maintenance costs. The magnet is used to align the nuclear spins of the hydrogen atoms of the body. The radio frequency transceiver transmits a radio frequency signal and picks up the signal released by the atoms within the body. This is the signal from which the images are made. The gradient coils allow the technologist to program the computer to obtain images of the part being studied in different body planes. The computer sorts information and produces images.

MRI cannot be used on a person with any type of metal within his/her body, whether it be a steel rod implantation or a small sliver accidentally embedded in the skin such as those found in steelworkers. Persons with pacemakers cannot be tested with the MRI scanner.

Sonography

Medical ultrasound or sonography was an application for imaging of military sonar used during World War II. Ultrasound waves are inaudible to the human ear as they are produced in a range above 20,000 hertz (cycles per second). An ultrasound machine is composed of a *computer* (central processing unit), hand-held *probes* used for scanning various body parts, and a *photographing device*. The computer has a viewing screen and devices for adjusting the images as they appear.

Each probe functions as a transducer. The transducer changes electrical impulses into sound waves which are bounced off body tissues. The tissues differ in density, size, shape, and elasticity. Ultrasound waves have different velocities in the different tissues. These rates can be measured and used to generate images. The probe emits a pulse of ultrasound and will receive the sound wave bounced back from the tissue. Different probes are available for examination of a specific organ. The recorded image is called a *sonogram*.

Several different ways are used to record examinations. The sonogram may be similar to an x-ray or may be recorded on black-and-white photographic film. Videotapes can be made for special studies. In echocardiography, the heart action is studied using ultrasound to document heart motion and heart structure on videotape.

Nuclear Medicine Equipment

Nuclear medicine equipment is complex, sensitive, and expensive for emission scanning. It consists basically of a gamma camera, TV equipment, and a photographic film device.

First a patient is given a specific radioactive chemical. These substances may be ingested, injected, or inhaled. These will circulate through the body and concentrate in an organ. Gamma rays will be emitted. A *gamma camera* is used to detect the varying amounts of gamma rays given off at the organ site (see fig. 3).

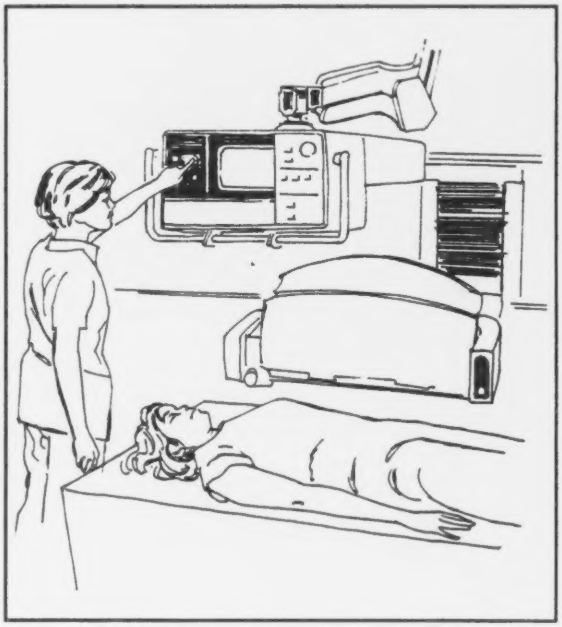


Fig. 3. Nuclear medicine scan by gamma camera

The camera is placed over the patient. When the gamma rays from the patient strike the crystal in the camera, the rays are recorded as flashes of light. Through complex electronics, the light given off from the camera is changed into a picture. The picture appears on a TV screen for study. At the same time, a photographic film is exposed to produce a permanent record. Different intensities in radiation are used to form the image. The record is called a *scintigram* or *scintiscan*. The gamma camera may also be called a *scintillation camera* since it records the gamma rays as flashes of light as they strike the crystal.

Another piece of equipment used in nuclear medicine is a *well counter*. After the patient receives radioactive material, a sample of body fluid, such as blood or urine, is collected. The counter has a scintillation crystal with a hole or "well" in the center. It counts radioactive samples and produces a numerical value, not a picture.

Summary

Radiographic, fluoroscopic, and mobile equipment is described. The use of contrast media is explained. Tomography is compared with computed tomography scanning, developed by Godfrey Hounsfield. The equipment used in magnetic resonance imaging, sonography, and nuclear medicine is discussed.

4

Protection from Radiation and Infection

Objectives: After completing this unit, you will be able to—

1. *differentiate between somatic and genetic effects of radiation;*
2. *determine the maximum permissible dose at different ages;*
3. *describe the two types of monitoring devices: film badge and thermoluminescent dosimeter;*
4. *describe the three primary principles of radiation protection;*
5. *name three types of protective apparel;*
6. *explain why radiology department personnel should not be used to hold patients during radiographic examinations;*
7. *name the legislative acts that provide for standards and the agencies that regulate the radiology department; and*
8. *describe the responsibilities of the radiologic technician in regard to asepsis.*

Terms and Definitions

asepsis—prevention of the spread of diseases from one person to another.

barrier—shield of radiation-absorbing material or materials used to prevent spread of disease.

chromosome—a structure in a cell that transmits genetic information.

communicable disease—a disease that can be passed from one person to another.

crystal—solid body in which atoms are arranged in definite, symmetrical patterns.

density—mass per unit volume.

dosimeter—an instrument used to detect and measure an accumulated dose of radiation.

film badge—plastic holder containing small film sandwiched between metal filters; an instrument used to measure an accumulated dose of radiation.

immobilization device—equipment used to prevent patient movement.

ionizing radiation—produced by x-ray machines or by the natural decay of radioactive elements.

maximum permissible dose (MPD)—dose of radiation that is not expected to cause appreciable bodily injury to persons at any time during their lives.

rem—a unit of measurement of radiation exposure for humans.

secondary or scattered radiation—occurs when portions of the x-ray beam are deflected or bounced off surrounding tissue into the atmosphere.

thermoluminescent dosimeter—instrument containing a small crystal which, when exposed to radiation, absorbs energy and stores it in the form of electrons; used to measure accumulated dose of radiation.

It was probably not long after the discovery of x-rays and their application to medicine that radiation workers began to realize radiation could have harmful effects. It is sometimes difficult for inexperienced radiology personnel to understand the dangers of radiation because it cannot be seen, heard, or felt, although its results can be seen on radiographs. *Ionizing radiation* occurs naturally by the decay of radioactive elements and through the use of x-ray machines. Organs particularly affected by radiation are the skin, eyes, blood-forming tissues, and the gonads.

Two types of damage result from radiation exposure: genetic effects and somatic effects.

1. *Genetic effects* refer to chromosome damage caused by exposure to radiation, whereby future generations may be affected.
2. *Somatic effects* refer to cells and tissues damaged by exposure to radiation. Somatic effects are the effects suffered by the person receiving the exposure.

Occupational Exposure

Any radiation exposure may be injurious. However, health physicists have identified a maximum permissible dose for radiation workers. The dose of radiation that is not expected to cause appreciable bodily injury to persons at any time during their lives is called the *maximum permissible dose (MPD).* Maximum permissible dose is measured in rems. A *rem* is a unit of measurement of radiation exposure for humans.

The radiation worker is allowed to receive a maximum dose to the whole body of 5 rems per year after the age of 18. The formula for maximum permissible dose (MPD) in rems is:

$\text{MPD} = 5(N-18)$

Where N = age in years

For example: What would be the maximum permissible dose for a radiation worker 30 years of age?

$\text{MPD} = 5(30-18)$

$\text{MPD} = 5(12)$

$\text{MPD} = 60$ rems

What would be the maximum permissible dose for a radiation worker 40 years of age?

$\text{MPD} = 5(40-18)$

$\text{MPD} = 5(22)$

$\text{MPD} = 110$ rems

By applying this formula, it becomes evident that MPD can be compared to a bank account. At age 30, the worker has 60 rems in her account and at age 40, she has 110 rems in her account if she has not been previously exposed to radiation. It is also evident that persons under 18 years of age should not be employed in occupations dealing with radiation. They may, however, assist radiology personnel.

Maximum permissible dose does not include any radiation exposure the worker might receive as a patient because the diagnostic information gained by the worker's physician could outweigh any risk involved.

The highest doses of radiation to diagnostic personnel are generally received during fluoroscopy and mobile radiography. During radiography, the worker should remain behind a protective barrier. Such barriers are usually not available for mobile radiography. Fluroscopic procedures usually require the radiographer to remain in the room during the examination unless remote control fluoroscopy is available. However, other protective measures may be used in both instances.

One of the main sources of exposure for the radiology department worker is *scattered* or *secondary radiation.* This effect results from portions of the x-ray beam being deflected or bounced off the tissues through which it passes. It disperses randomly through the atmosphere. Current machines have lead-lined cones to restrict the beam's travel to one direction in an attempt to reduce scattered radiation.

Although an MPD for radiation workers has been established, the radiographer should strive to receive the lowest possible exposure. Some of the effects are cumulative, lasting for years. Since radiographers are routinely exposed to radiation, it is important to determine the amount of radiation they receive.

Personnel Monitoring

Two methods can be used to monitor the quantity of radiation received (see fig. 1) which are acceptable for compliance to standards. A pocket ionization chamber, or dosimeter, resembling a fountain pen, is no longer acceptable.

A film badge is used by many radiology departments for personnel monitoring. A number of laboratories specialize in supplying and reading the film badges. A *film badge* is a plastic holder containing a small piece of radiographic film sandwiched between metal filters. The filters allow the laboratory to determine the energy level of the radiation that exposed the film.

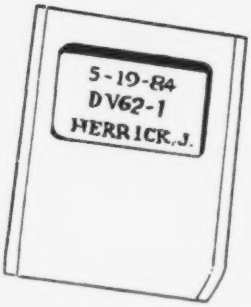


Fig. 1. Film badge for personnel monitoring

A more accurate method of determining radiation exposure is by using a *thermoluminescent dosimeter*. The TLD contains a small crystal which, when exposed to radiation, absorbs energy and stores it in the crystal lattice in the form of electrons. When the crystal is heated under controlled conditions, the electrons return to their normal state, and the energy is released in the form of light. The light is measured by a photomultiplier tube crystal.

Either of the monitoring devices described should be worn on the collar. A second dosimeter can be placed under the apron. The combination of these two will allow evaluation of both whole-body exposure and neck exposure. Whatever type of monitoring device is used, state and federal regulations require that the results be maintained. If one changes employment, the total radiation exposure history must be transferred to the new employer. The radiation worker should also receive a copy of the radiation monitoring record.

Another type of monitor can be placed in a treatment room to determine that radiation does not exceed acceptable levels. Alarms can be attached to the monitor. These sound to indicate high levels of radiation or when a door is inadvertently opened during radiation therapy procedures.

Principles of Protection

These primary principles of radiation protection are *time*, *distance*, and *shielding*.

- The amount of radiation received by an individual is directly related to the *time* of exposure. If the time of exposure is doubled, then the radiation dose will be doubled.
- *Distance* constitutes one of the best and least expensive methods of radiation protection. It might be thought that if one doubled the distance from the source of radiation then the exposure would be reduced to one-half. Instead, it is reduced to one-fourth. This is known as the inverse square law. For the best protection, stay as far away from the source of radiation as possible (see fig. 2).
- Placing a dense object, or shield, between the radiation source and the worker reduces the level of exposure. *Shielding* in diagnostic radiology usually consists of lead placed in the walls of radiographic rooms. The control panel of the radiographic unit is placed behind a lead barrier with a lead glass window in it so that the worker can see the patient (see fig. 3).

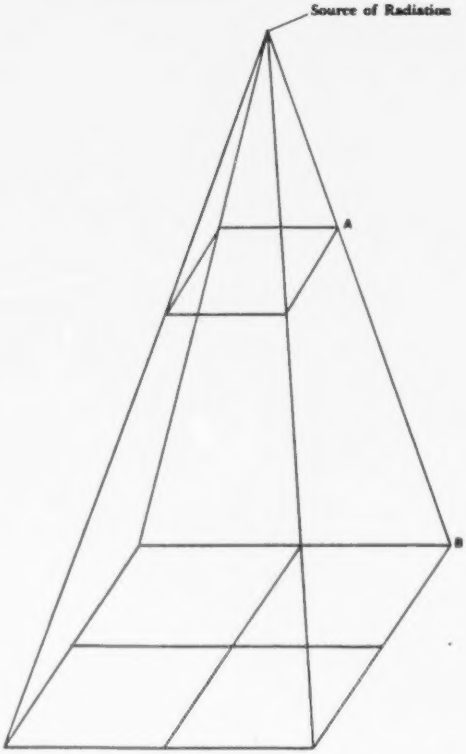


Fig. 2. Inverse Square Law: At double the original distance, the radiation is spread over an area four times larger. Area B receives one-fourth as much radiation as area A.

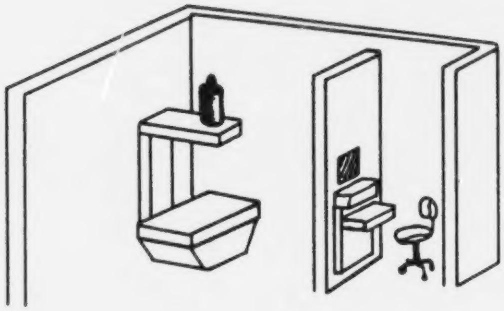


Fig. 3. Control panel shown behind a lead barrier

Protective Apparel

Protective apparel is available in the form of aprons, gloves, and goggles made of vinyl or rubber and containing lead (see fig. 4). These are useful during fluoroscopic and mobile unit examinations when a fixed protective barrier cannot be used. Protective devices supplied with the equipment, such as protective pull-up panels or lead drapes, should be used when available.

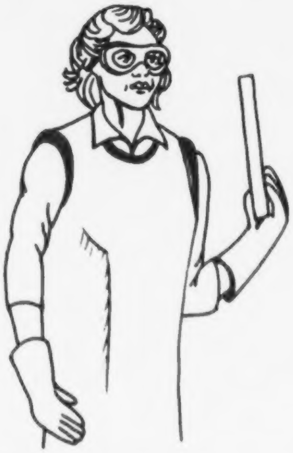


Fig. 4. Rubber apron and gloves to protect from radiation.

Immobilization

Devices such as sandbags or compression bands to immobilize and restrain patients should be used for patients who are not able to support themselves (see fig. 5). To avoid radiation exposure, personnel of the radiology department should never hold patients for radiographic examinations.

The radiographer should take that little extra time to apply immobilization devices. If for some reason immobilization cannot be used, a relative accompanying the patient may be asked to assist. Any person holding the patient should be provided with a lead apron, gloves, and goggles.

Regulation

The general public and the government have become very concerned about exposure to radiation. Required federal standards for medical x-ray equipment went into effect August 1, 1974, under the Radiation Control for Health and Safety Act. Specifications include many safety features to aid in patient protection.

The Consumer-Radiation Health and Safety Act, signed August 13, 1981, specifies that only competent, licensed technologists will be able to expose patients to radiation. The states were allowed a period of three years to design and pass legislation complying with this act.

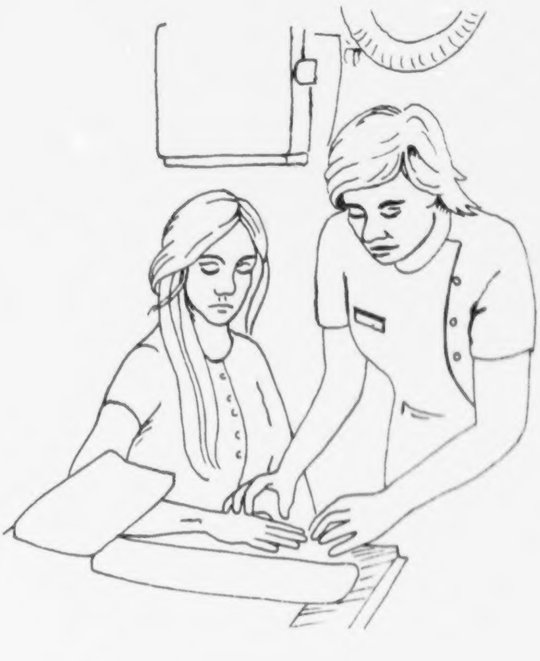


Fig. 5. Use of immobilization devices

Medical Asepsis

Medical asepsis means the prevention of the spread of disease-producing organisms from one person or place to another. All health care workers must constantly be aware of the danger of infecting patients or themselves with contagious bacteria or viruses. A primary goal must be to keep the radiology department clean and free of disease-producing microorganisms at all times. The problem is complicated because many patients needing medical care are already suffering from infections.

The health care worker must become aware of the three ways by which disease can be spread. One way is *indirectly* by the use of contaminated equipment or contact with contaminated objects. For example, the HIV virus is spread by use of contaminated needles. A second way is by *direct* contact between persons—patients, workers, and family members. Tuberculosis bacteria and the viruses causing the common cold, mumps, and AIDS are spread directly from person to person. Besides these two methods of disease transmission (*indirect* and *direct*), a third method exists. Transmission of disease by body waste is the *enteric* route. Hepatitis is an example of a disease spread by this method.

Radiology personnel must protect themselves by practicing good health habits, getting enough rest, eating properly, and being aware of the importance of medical asepsis. One of the most important things to learn is aseptic hand washing. The hands should be washed before and after caring for each patient, after toileting, on leaving isolation, after handling soiled equipment, and always before eating.

Gloves, gowns, and masks are donned by radiology personnel when taking mobile equipment into isolation or when patients from isolation are brought in for radiographs. Gloves should be worn for any invasive procedure or when contact with the patient's body fluids or excreta is a possibility. Protective garments serve as barriers to diseases.

If work surfaces become contaminated, they may be cleaned with a disinfectant solution and rinsed with a damp cloth. The need for sterilization or disinfection of instruments has decreased with the development of presterilized, individually packaged, disposable equipment. Even masks, gowns, drapes, and sheets have become disposable through adaptations of paper. The major obligation remaining with one-use supplies is proper disposal, using aseptic techniques, for the protection of all. Remember that sharps must be discarded into punctureproof containers. Universal Precautions must be practiced.

Radiation exposure to radiology department personnel will be at a minimum if all personnel take advantage of the protective devices and equipment provided and observe the principles of protection. Department personnel also have the obligation to practice medical asepsis for the protection of themselves, patients, and co-workers.

Summary

The genetic and somatic effects of radiation are cited. Maximum permissible dose is defined and explained. Protective devices are listed, and the importance of medical asepsis is emphasized.

5

Radiology Office Records and Procedures

Objectives: After completing this unit, you will be able to—

1. *describe the proper way to answer the telephone;*
2. *compare verbal and nonverbal communication;*
3. *describe the preparation given to the patient for the following radiographic examinations:*
    - *a. upper gastrointestinal series,*
    - *b. gall bladder examinations,*
    - *c. lower gastrointestinal series, and*
    - *d. intravenous pyelogram;*
4. *name the contrast materials used for radiographic studies;*
5. *explain how the organs are made visible;*
6. *state the purpose of a mammogram;*
7. *explain the types of studies which may be conducted using—*
    - *a. CT scanning,*
    - *b. nuclear medicine,*
    - *c. ultrasound, and*
    - *d. magnetic resonance imaging; and*
8. *describe the terminal digit system of filing.*

Terms and Definitions

alimentary tract—digestive system extending from mouth to anus.

barium sulfate—fine, white powder used as a contrast material in radiology.

biopsy—the removal of a small piece of tissue for diagnostic microscopic examination.

colon—large intestine leading from the cecum to the rectum.

emission scanning—procedure for recording radioactive emissions from substances taken into the body by ingestion, injection, or inhalation.

esophagus—tube for the passage of food from the pharynx to the stomach.

feces—digestive wastes in the intestines.

gall bladder—small, muscular sac, located under the right lobe of the liver that stores bile excreted by the liver.

kidney—either of a pair of structures that remove wastes, such as urine; maintain proper water balance; and regulate acid-base concentration.

nonverbal—communication without words.

small intestine—part of the digestive tract from the stomach to the colon.

ureter—either of a pair of long, narrow tubes that carry urine from the kidney to the bladder.

urinary bladder—membranous, saclike structure for holding urine.

The radiology office personnel perform very important functions in the department. Duties of the personnel include answering the telephone, scheduling patients' appointments, explaining examination preparation procedures to patients and hospital staff, and keeping records.

The Telephone

The telephone should be answered promptly and in a courteous, professional manner. The person answering the telephone should say, "Radiology Department, Miss/Mr. Smith." All messages, no matter how short or simple, should be written down as they are being given by the caller. It is easy to become so busy that the message is soon forgotten. If it is necessary to find information that will take longer than one or two minutes, the caller's number should be taken. Once the information is available, the call should be returned and the required information given. When a caller is placed on "hold," the operator should check back often to assure that requested information is being gathered.

Every telephone conversation should end on a pleasant note. The caller ends the conversation. You say a pleasant "good-bye" and let the caller hang up first.

Communicating with Patients

Patients who enter the radiology department should be greeted in a warm, friendly but professional manner. Coolness and disinterest have no place in a health care setting.

The patient may first contact radiology by telephone. The second contact comes in the reception area. All patients must be identified correctly by name. In a hospital, a patient who is very ill or incapacitated may arrive by wheelchair or stretcher. The accompanying nursing personnel announce the arrival of this patient quietly to office personnel. The arrival of all patients should be acknowledged immediately.

Special attention should be given to children. Parents usually appreciate help in settling a child in a strange setting. The elderly and handicapped require an added measure of consideration. Office personnel must be quick to judge how much assistance is needed without infringing on the individual's independence.

Personnel should introduce themselves to a blind patient and offer assistance. If the blind person is accompanied, this person can usually be relied upon for help. If the patient is deaf, all means of communication should be used to complete procedures or provide treatment. Means of communication may include gestures, sign language, use of a signing interpreter, written notes, or merely facing the deaf person and speaking clearly for ease in hearing or lip reading. A list of interpreters, available on call, should be kept for occasions when patients appear who do not speak English.

The art of communication involves three factors—a sender, a message, and a receiver. It is very important that the receiver interpret the message as the sender intended. We also communicate nonverbally as well. Studies have found that nonverbal communication is more accurate than verbal. It is difficult for a patient to believe you mean "good morning" when you slam the door as you enter, frown, and speak through clenched teeth. Radiology workers should be careful at all times to use facial expressions and gestures to reinforce verbal communication. If you smile as you say "good morning," the message is believable.

Appointments

A number of radiographic procedures require that the patient follow some type of special preparation before reporting for the examination. The radiology aide must be familiar with the examinations and required preparations. If the patient is in the hospital (an inpatient), the nurse in charge of the patient's floor will prepare the patient. In the case of outpatients, the radiology office personnel will likely schedule the appointments and explain the preparations to patients.

The following examinations are often done on an outpatient basis. Because some examinations discussed in this unit require that the patient not have anything to eat or drink for a period of time before the radiographic procedure, it is best to schedule the patient as early in the day as possible.

Upper Gastrointestinal Examination (G.I. Series)

The upper gastrointestinal examination includes the esophagus, stomach, and sometimes the small intestine. Since the alimentary tract does not have sufficient density to be distinguished from surrounding structures, it is necessary to use a contrast material. Barium sulfate is usually given for this purpose. The powdered barium sulfate is mixed with water until it is the consistency of cream. Most departments use a flavored barium so that it will be more pleasant for the patient. Barium sulfate can be purchased in bulk or in individual plastic cups ready to be mixed with water.

When the patient reports to the radiology department with an order from the doctor for a G.I. series, the worker schedules an appointment time and explains the preparation the patient is to follow. It is important for patients to understand the reason for the preparations they are given before the examination. Since the stomach must be empty for the radiographic examination, both food and water are withheld after midnight, usually for a period of eight to nine hours.

When the patient reports to the department on the day of the examination, he or she is asked to remove all clothing except shoes and is given a gown. During the examination, the radiologist fluoroscopes the patient as the patient drinks the barium sulfate. After the fluoroscopic examination, the technologist takes a series of radiographs of the stomach.

Gallbladder Examination (Cholecystogram)

The gallbladder is a small sac (3 to 4 inches long and 1 inch wide) that stores the bile that aids in digestion. Since the gallbladder is about the same density as the structures surrounding it, it must be filled with a contrast material in order to be seen.

The contrast medium for a gallbladder examination is tablets containing iodine. Several companies market gallbladder media. About 10 to 12 hours before the gallbladder examination is scheduled, the patient is instructed to take the tablets (usually six) with as little water as possible. This is usually about two to three hours after the evening meal. The patient must not have food after the meal but may drink liquids up to bedtime.

Some departments require the patient to eat a fatfree evening meal. This is because fatty foods cause the gallbladder to empty. The fatfree meal prevents the gallbladder from emptying the contrast material along with the bile.

When the patient reports to the department on the day of the cholecystogram, he or she is asked to remove all clothing except shoes and is given a gown. The gallbladder examination consists of a series of radiographs taken by the technologist to demonstrate the gallbladder in various positions.

Lower Gastrointestinal Examination (Colon, Barium Enema)

Examination of the large intestine or colon is carried out by giving the patient an enema of barium sulfate mixed with water. A second method is performed in two parts. The colon is filled with barium sulfate and water and, immediately following evacuation of the barium, an air enema is given. The barium sulfate or the combination of barium sulfate and air will demonstrate most abnormalities of the colon. Powdered barium sulfate can be bought packaged in plastic, disposable bags. It is necessary simply to add water and mix thoroughly. This type of bag has the tubing and enema tip attached.

It is very important for the patient to be properly prepared for an examination of the colon. The colon must be completely free of any fecal material before the examination can be carried out successfully. Preparation usually consists of the patient taking a laxative, such as castor oil, the afternoon before the examination. Water must be taken hourly during the afternoon prior to examination as adequate liquids are necessary for the laxative to take effect. In addition, the patient is instructed to take a clear water enema on the morning of the examination. The patient can have nothing to eat the day before or on the day of the examination.

Because the extensive preparation may weaken the patient, the radiology worker should be as helpful to the patient as possible. When the patient reports to the department on the morning of the examination, he or she should be instructed to remove all clothing except shoes and to put on a gown.

The radiographic examination is begun by the technologist who inserts the enema tip. The radiologist fluoroscopes the patient and watches the colon as it is filled with barium sulfate. When the colon is filled, the technologist takes a series of radiographs. Then the patient is helped to a restroom by the technologist or aide and instructed to evacuate as much of the barium sulfate as possible. Then the technologist takes a final radiograph.

Intravenous Pyelogram (IVP)

Intravenous pyelography is a radiographic examination of the urinary system. A radiopaque contrast material containing iodine is injected by a radiologist into a vein of the patient's arm. Radiographs are taken of the patient in a timed sequence following the injection. These films of the abdomen provide information about the structure and function of the kidneys, ureters, and bladder. The contrast medium is essential because the urinary structures are not identifiable on plain radiographs.

Because the kidneys lie behind the intestines, it is essential that the intestines be free of any gas or fecal material. The patient is instructed to take a laxative, such as castor oil, on the afternoon before the examination. The patient can have nothing to eat and only small sips of liquid on the day of the examination.

When the patient reports to the radiology department on the day of the examination, he or she is instructed to remove all clothing except

TABLE 1

Preparations for Radiographic Examinations

Upper G.I. Series

Nothing by mouth after midnight

Barium Enema (Lower G.I. Series)

1. On the day before the examination, eat no solid foods. It is important to drink a lot of fluids, such as soft drinks, soup, fruit juices, and Jell-o.
2. Take two ounces of mineral oil, castor oil, or other prescribed laxative at 12:00 noon the day before the examination.
3. Drink one 8-ounce glass of water each hour from noon until 8:00 P.M. the day before the examination. You must have adequate liquid for the laxative to be effective.
4. Take 2 1/2 ounces of x-ray preparation at 6:00 P.M. the day before the examination. Mineral oil or other laxative may be substituted.
5. On the morning of the x-ray, you should have a single clear water enema of 2 quarts volume at approximately 5:00 A.M. Try to retain the full volume before expelling any of it. Repeat the enema, if necessary. You may continue to have small amounts of clear liquids, such as coffee, on the morning of the examination.

Gallbladder Examination

1. Take the six gallbladder pills at 9:00 P.M. Swallow them at 2-minute intervals using sufficient water to swallow.
2. After the evening meal, eat no solid foods until the examination is completed. You may have liquids until 10:00 P.M. but after that time, you may have only small sips of water.

IV Pyelogram

1. Take 2 1/2 ounces of x-ray preparation at 6:00 P.M. on the evening before the examination. If the colon is to be x-rayed the same day, follow the preparation for the barium enema.
2. On the day of the examination, do not eat solid foods.
3. Small amounts of liquid, including coffee, on the morning of the x-ray are permitted.

shoes and to put on a gown. The patient is then escorted to the radiographic room where the examination is performed. Table 1 is a summary of all of these preparations.

Flat-Plate X-Ray

One type of x-ray does not require extensive preparation or involve the use of radiopaque substances. Films produced by this method are called *flat plates*. These are simply pictures of a body part or a foreign body lodged in the tissues. Commonly, x-rays of the chest, skull, and upper or lower extremities are produced by this method.

Mammogram

A *mammogram* is an x-ray of the breast. A woman is usually referred by her physician after an examination by palpation during an office visit. Suspicious lumps may or may not be present. No special preparations are needed. However, no underarm deodorant, perfume, or powder should be worn on the day of the test. The patient assumes several positions before the machine, and the breasts are compressed. Several views are taken of each breast. This test is an x-ray examination of the internal tissues of the breast for cancer.

CT Scanning

The most common use of the CT scanner is for examination of the head for injury or neoplasms. The patient will be asked to remove jewelry, glasses, hair ornaments, and any other item which might be on the head. The patient is placed on the transport system table with the head secured in a cradle. The patient is instructed to remain as still as possible. The table moves the patient's head into the gantry where x-ray exposures can be made by rotating the x-ray tube through a 360° circle as the console controls are adjusted.

Another application of this system is in diagnosing growths, lesions, and inflammation of the abdominal area. The CT computer is able to measure the exact size and depth of a growth. The radiologist can also do a biopsy using the CT scanner to guide the biopsy needle to the site for removal of a tissue sample. A *biopsy* is the removal of a small piece of tissue for microscopic examination to determine a diagnosis. This may be done on an outpatient basis.

Nuclear Medicine Examinations

One of the most common nuclear medicine procedures is called *emission scanning*. In this procedure, the patient is given a small amount of radioactive material tagged with a pharmaceutical (chemical compound), which travels through the body to concentrate in a specific organ The radioisotope gives off gamma rays continuously. The patient sits or lies down in front of the gamma camera which records the emissions using a scintillation crystal. Some of the commonly performed scans are the thyroid uptake, bone scan, and lung scan. Special scans are done for cardiac diagnosis and care. Patients must be watched for any reaction to the pharmaceutical or radioisotope.

Contrast Media Reaction

A word of caution needs to be given concerning possible allergic reactions to contrast media. Patients should be carefully questioned for allergic episodes in the past, especially involving iodine, before x-ray studies are begun. Sometimes the tablets, containing iodine, given for gallbladder examination will cause nausea and diarrhea. The intravenous injection given for a pyelogram also contains iodine. After the injection, the patient should be watched for flushing. Some report a metallic taste. Itching and shortness of breath should be reported to the radiologist as this may indicate allergic reaction.

Ultrasound

Ultrasound examination may be conducted on many body areas. This technique is often used for female pelvic examinations to diagnose pregnancy and differentiate conditions associated with pregnancy.

Ultrasound examinations are used to diagnose the presence of gallstones and kidney stones. One type of ultrasound (low frequency) is used to diagnose the stones' presence, and another type (high frequency) is used to break up the stones. The procedure for breaking up these stones is called *lithotripsy*. It saves patients from surgery.

Other parts of the body photographed by ultrasound are the male pelvis, the thyroid, and the soft tissues of the knee. The heart can also be imaged. The process is called *echocardiography*. This imaging (called an *echogram*) provides information on how the heart valves and muscles are working.

Doppler ultrasound is used to measure blood flowing through the arteries and veins. Doppler ultrasound distinguishes between normal and abnormal blood flow to detect clots in arms, legs, the abdomen, and transplanted organs.

Magnetic Resonance Imaging

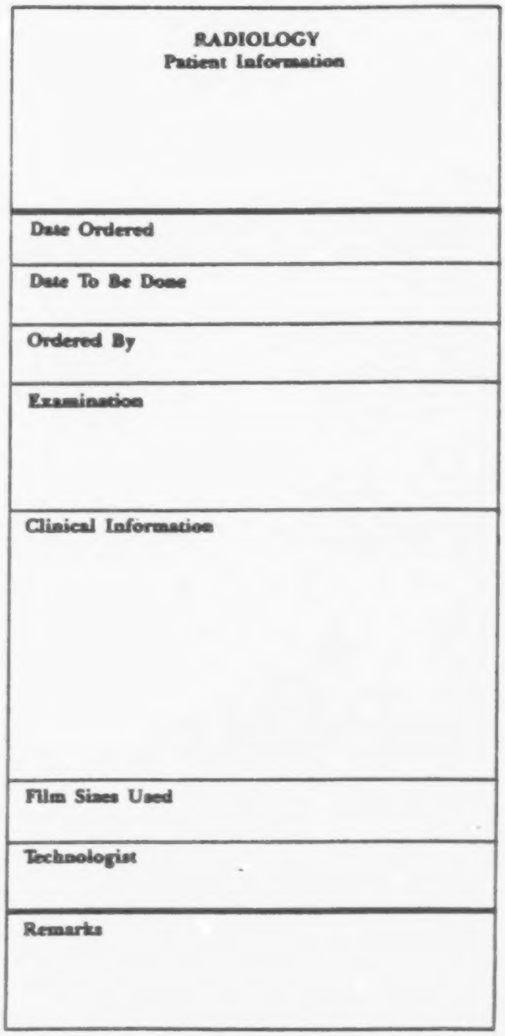
Magnetic resonance imaging (MRI) techniques are used for studies similar to those using the CT scanner. MRI produces images in more body planes in less time and without exposure to radiation associated with CT scanning. It does not work well for visualization of bone, nor can it be used on people who are claustrophobic or have any metal in their skin or within their bodies.

Record Keeping

It is required that a physician order all radiographic examinations. Radiology departments have standard request forms for radiographic procedures (see fig. 1). In addition, each department has its own record-keeping procedure. The procedure described in this unit is typical of most radiology departments.

When the request is received, it is necessary first to determine if the patient has had previous radiographic examinations. This information is generally kept in a card file, in alphabetical order by the patient's name. On this information card is found the patient's name, address, sex, age, and case number. Each radiographic examination of the patient is listed along with the date of examination (see fig. 2). The new examination and date are added to the card. If the patient has no previous radiographs, a card is prepared.

In order for the patient's radiographs to be identified, an identification card is prepared containing the patient's name, address, sex, age, case number, and other information required by the department. This information is placed on the patient's radiographs by means of lead letters and numbers which are placed on the casette. After exposure, the information is on the film permenantly. Another method uses radiopaque tape. Patient information is typed on the tape. The tape is attached to the cassette before exposure.



RADIOLOGY
Patient Information

Date Ordered

Date To Be Done

Ordered By

Examination

Clinical Information

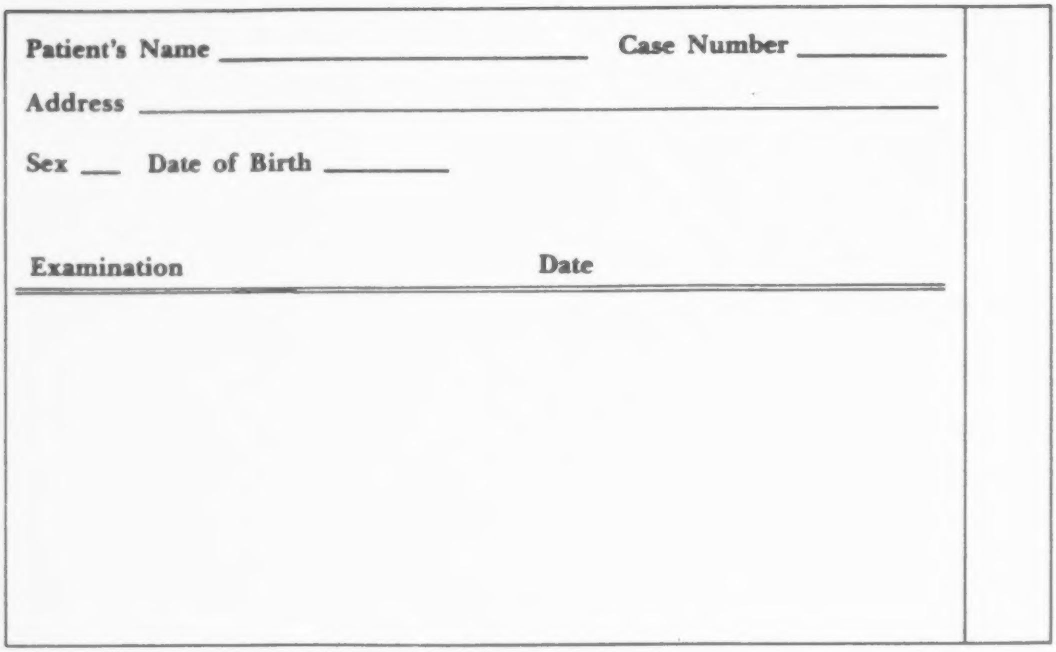
Film Sizes Used

Technologist

Remarks

Fig. 1. Typical radiology request form

After the radiographic examination is completed, any previous radiographs are pulled from the file and given to the radiologist, along with the new examination. The ra-



Patient's Name ____________ Case Number ________

Address ______________________

Sex ___ Date of Birth ________

Examination	Date

Fig. 2. Patient information card

Fig. 3. The radiologist reading x-rays to prepare a report

diologist reads the new radiographs and dictates a report of the findings (see fig. 3). A secretary prepares the report. A copy of the report is put in the jacket with the patient's radiographs, another copy in a file, one copy is put in the patient's hospital chart, and a copy is sent to the patient's doctor. The radiographs are then filed by case number. In most hospitals the patient's case number is used on all charts, radiographs, laboratory reports, and other records.

An easy-to-use numbering system is the terminal digit system. This system uses three groups of numbers, two in each group. The radiographs are filed by the last two numbers first, then the first number of the second group (see fig. 4).

In many large radiology departments, the record-keeping system is done by a computer. The same information is required. An aide enters the patient information into the computer. The computer responds with information concerning that patient, similar to the information on the typed information card. The computer may also print out the card used for film identification. Other information may be available from the computer, such as a printout at the end of the day, listing all cases for that day and charges.

Because it is important for a physician to have information available on his or her patients, the record-keeping system is very important. Information must be accurately recorded and films filed properly.

Summary

Radiology office procedures include techniques for answering the telephone, communicating with patients, both verbally and nonverbally, making appointments, and describing the preparations for radiologic examinations. The following procedures are outlined: upper gastrointestinal examination, gallbladder examination, lower gastrointestinal examination, intravenous pyelogram, flat plates, and mammogram. Cautions concerning contrast media reactions are given. Examples of the uses of CT scanning, nuclear medicine, sonography, and magnetic resonance imaging are listed. Required records and their filing are discussed.

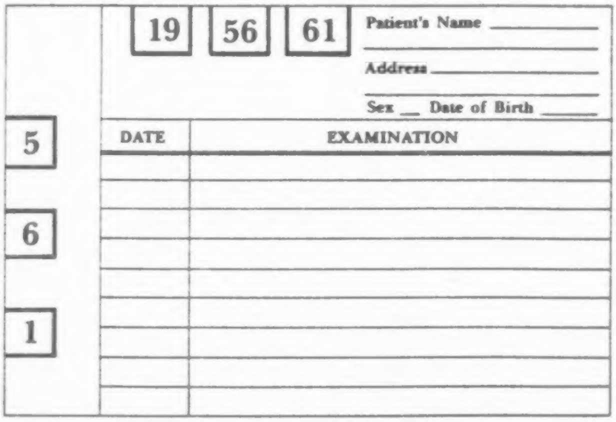


Fig. 4. Radiographic film folder using terminal digit system

6

Patient Care and Transportation

Objectives: After completing this unit, you will be able to—

1. *describe good posture;*
2. *demonstrate good body mechanics;*
3. *outline rules to remember when moving patients;*
4. *list three ways of transferring patients;*
5. *describe the methods of transferring patients from a wheelchair and from a stretcher to the x-ray table; and*
6. *describe three methods of assisting a patient to walk.*

Terms and Definitions

alignment—parts in proper relationship to one another.
ambulatory—able to walk without assistance.
balance—stability produced by equal distribution of weight.
base of support—portion of the body that is in contact with the floor.
body mechanics—principles of proper body alignment, movement, and balance.
center of gravity—the point at which the mass of any body is centered.
gravity—attraction of a mass or body to the earth.
line of gravity—imaginary line passing through the center of gravity.
prone—lying face downward.
supine—lying face upward.
trunk—body or torso apart from head and extremities (arms and legs).

When a patient is brought to the radiology department, it is important to make that person feel as comfortable and secure as possible. Before the patient is brought into the x-ray room, check to make certain you have the right person. Be sure the name is spelled correctly. Occasionally, there will be two patients in the department with the same name, the same initials, and very nearly the same problem.

Check the patient's identification bracelet with the x-ray request, and ask for the patient's name as a double safeguard. The birth date on the x-ray request may also give you a clue as to whether or not you have the correct patient. If the patient is elderly and the birth date indicates the patient is young, you would know you have the wrong patient.

Donning a Gown

Many radiographic examinations require that patients remove all or part of their clothing and put on a gown before the examination is performed. When the outpatient arrives in the radiology department, she/he should be escorted to a dressing room by the aide. At that time, the aide should explain to the patient what clothing should be removed and how the gown is to be worn. Some gowns open in the back, some open in front, and others are the wraparound type with three arm openings. The aide should offer to help the patient undress and remain near the dressing room to assist if needed.

Many patients bring jewelry, a purse, or a billfold to the department. Valuables should not be left in dressing rooms. If the department does not have a designated area for safekeeping of valuables, patients should be instructed to take these articles with them to the radiographic room.

Generally, a patient who is in the hospital will be able to put on the gown with only minimal assistance. If it is necessary for the aide to gown the patient, the patient should be covered with a sheet. The clothing is removed from the less affected side first and then from the affected side. The gown should be placed on the affected side first and then on the unaffected side. The patient should be kept covered with the sheet during this time. After the patient is properly gowned for the examination, he or she is taken to the x-ray room.

Body Mechanics

To assist the patient in moving on and off the x-ray table requires that the technologist and aide have a knowledge of body mechanics. *Body mechanics* refers to the principles of proper body alignment, movement, and balance.

The use of good body mechanics will help prevent the radiology aide and the technologist from getting injuries, such as muscle and back strain. The technologist or aide will be less tired and avoid personal injury if the rules of good body mechanics are followed. These rules are based on the laws of gravity. *Gravity* is a force that pulls objects toward the center of the earth. Any movement made requires an expenditure of energy to overcome the force of gravity. When an object is balanced, it is firm and stable. If it is off-balance, it will fall because of the pull of gravity.

You should remember that the largest parts of our bodies (head, chest, and pelvis) are supported by parts that are very small (legs and feet). So balance is important. The three principles that affect balance are—

1. *center of gravity*—the point at which the mass of any body is centered. When a person is standing, the center of gravity is the center of the pelvis.
2. *base of support*—the portion of the body that is in contact with the floor. The base of support provides the stability to keep the body from toppling over.
3. *line of gravity*—an imaginary line that passes through the center of gravity (see fig. 1).

Good body mechanics requires good posture. Good posture means that the body is in proper alignment with all parts in balance. Here are general rules for correct upright posture:

1. Stand with the feet parallel and at right angles to the lower legs. Feet should be about 4 to 8 inches apart. Keep body weight equally distributed on both feet.
2. Keep the knees slightly bent because this acts as a shock absorber for the body.
3. Keep the buttocks in and the abdomen up and in. This prevents strain on the back and abdominal muscles. The chest should be held up and slightly forward with the waist extended. This allows the lungs to expand and fill with air.
4. The head should be held erect. This puts the spine in proper alignment.

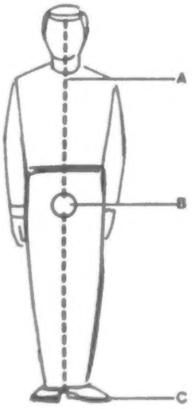


Fig. 1. (A) Line of gravity, (B) center of gravity, and (C) base of support.

These are some rules of good body mechanics that all health workers should learn (see fig. 2):

1. Provide a stable base of support with the feet separated and one foot slightly ahead of the other. Keep the trunk in a fairly straight position.
2. Keep the weight evenly distributed on both feet and the knees slightly bent.
3. Keep work close to the body to avoid stretching and reaching.
4. Work at a comfortable height to minimize muscle strain. Bend the knees when reaching near the floor.
5. Use smooth, coordinated movements.

When a heavy object must be lifted, balance the load over both feet, hold the load close to the body, bend the knees, and use arm and leg muscles to lift.

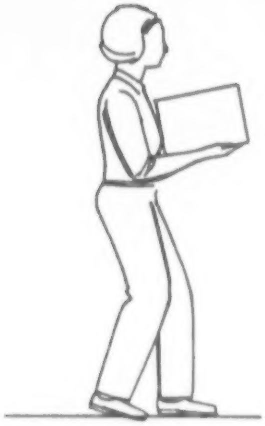


Fig. 2. Proper body mechanics

Safety Rules

A patient must not be moved without adequate assistance. To do so may cause injury to the patient or to the technologist. Some rules to remember when moving patients are these:

1. Give only the assistance that the patient needs for comfort and safety.
2. Always transfer a patient across the shortest distance.
3. Lock all wheels on beds, stretchers, and wheelchairs.
4. Generally, it is better to move a patient toward the strong side while the aide assists at the weak side.
5. The patient must be informed of the plan of the move, and is encouraged to help.
6. The patient should be given short, simple commands, and the technologist or aide must help the patient carry them out.

Methods of Transfer

There are three basic ways to transfer patients: by *stretcher*, by *wheelchair*, and by *patient ambulation*. When a patient is moved from a stretcher to a radiographic table, or the reverse, great care must be exercised to prevent injury. If the patient is unconscious or unable to cooperate in the move, the spine, head, and extremities must be well supported. One convenient way to do this is to place a sheet under the patient, and use it to slide the patient from one surface to another.

If the patient is an adult, three or four people should participate in the move. One person stands at the patient's head to guide and support it during the move; another should be at the side of the surface to which the patient will be moved; and the third person should be at the side of the surface on which the patient is lying. If there are four people, two may stand at each side. Refer to figure 3.

The sheet is rolled at the side of the patient so that the technologist can easily grasp it in the hands close to the patient's body. The team should be in agreement (usually by a count of one, two, three) about when the move will begin. Together, they transfer the patient to the other surface. Tube housing above radiographic tables should be moved out of the way when patients are being moved to protect both patients and workers from bumping into it in the moving process.

The technologist must never allow the patient to get off a table or into a wheelchair without assistance. The sudden movement may cause dizziness, and the patient may fall. When helping a patient move from a supine position to a sitting position, the technologist should have the patient turn to the side with the knees flexed. Then the technologist stands in front of the patient with one arm around the patient's shoulders and the other arm at the knees. Before assisting the patient to stand, allow him or her to sit for a moment and regain a sense of balance. The technologist may stand in front of the patient; bend the knees, flexing one against the table; place the arms at the patient's sides; and assist him or her to stand. If the patient needs only minimal assistance, the technologist may stand at the patient's side, taking the arm to assist the patient off the table.

The technologist should never allow a patient to step down from a radiographic table without providing a secure stepstool to step onto first before stepping to the floor.

If the patient is to be seated in a wheelchair, have the chair facing and close enough for the patient to be seated in the wheelchair with one pivot. It is important to have the foot supports of the chair up and the wheels locked. The technologist should stand in front of the patient

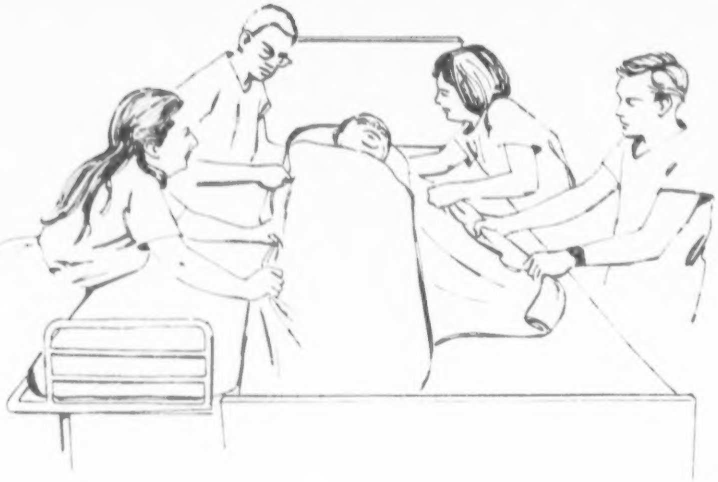


Fig. 3. Four person transfer from bed to stretcher

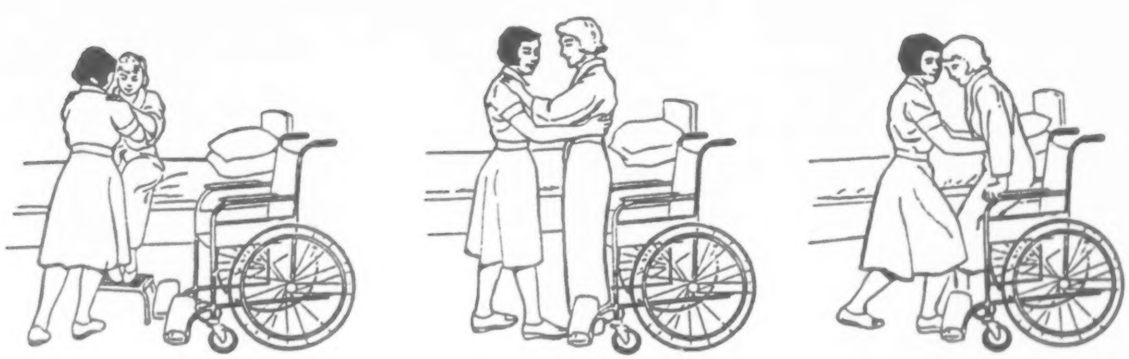


Fig. 4. Assisting a patient from bed to wheelchair

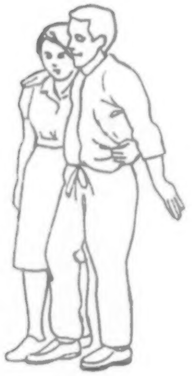


Fig. 5. Ambulating a patient

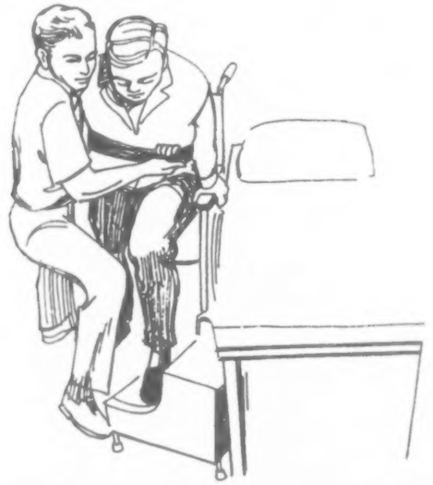


Fig. 6. Assisting a patient from wheelchair to treatment table using a transfer belt.

(spreading the feet for a broad base of support and flexing the knees), support the patient at the sides, pivot with the patient, and seat him or her in the chair. See drawings included in figure 4.

The patient must be kept covered as much as possible during any moving or transferring procedures and while on the radiographic table. A confused or unconscious patient or a child must never be left alone on a radiographic table or a stretcher. A restraint belt should be placed over all patients who are left on stretchers. If the stretcher has side rails, they should be up.

When assisting a patient to walk, walk at the side giving either—

1. *minimal* support (patient holds your elbow or hand);
2. *moderate* support (hold patient's hand and place the opposite arm around waist or ask patient to place one arm around your shoulders and place your nearest arm around the patient's waist); or
3. *more-than-moderate* support (give support to both sides of the patient). Moderate support for ambulation is shown in figure 5.

If a patient should fall, the technologist should assist in trying to break the fall so the patient slides easily to the floor. If a fall occurs, get a physician to see your patient to assure that the patient has not been injured.

Always keep the patient's welfare in mind. Remember that the patient is in unfamiliar surroundings in the radiology department. Figure 6 shows a patient being assisted onto a treatment table. It is up to the department personnel to protect and keep the patient as safe and comfortable as possible.

Dismissing the Patient

Upon completion of the radiologic examination, the patient should be asked to wait until the radiologist has verified that all needed films have been obtained. If other studies are required, radiology personnel should inform the patient that another film is needed for diagnosis. If the patient is told "the film didn't turn out well," the patient may think that the staff is incompetent, careless, and unconcerned about the cost of extra film to the patient.

Once the films are satisfactorily completed, the patient may dress. Assistance in dressing is offered. All personal property is returned. Records are checked for completeness. The patient is dismissed.

Empty dressing rooms should be checked. Soiled gowns are removed to a hamper. All paper products are discarded. New gowns, linens, and paper products are replenished from stores, as needed.

Summary

Patient care in regards to identification, gowning, and lifting is explained. The principles of body mechanics are enumerated. Patient safety is stressed for transporting and lifting. Three methods for assisting with patient ambulation are listed. Patient dismissal is discussed.

7

Radiographic Film and the Film Holder

Objectives: After completing this unit, you will be able to—

1. *name and describe the chemical composition of x-ray film;*
2. *identify the two basic components of x-ray film;*
3. *state the purpose of blue dye in film base;*
4. *describe how the emulsion is prepared and coated on the base;*
5. *describe the basic characteristics of film emulsion;*
6. *compare the use of the two main types of x-ray film;*
7. *cite additional types of radiographic film;*
8. *explain conditions to be considered in the storage of film;*
9. *describe the construction of a cassette; and*
10. *demonstrate the correct procedure for placing a film in a cassette.*

Terms and Definitions

base (film base)—flexible, blue-tinted polyester support for emulsion.

cassette—lightproof container for holding film and intensifying screen.

dosimeter film—film used in film badges to measure radiation dosage.

duplicating film—single-coated film used to make copies of radiographs.

emulsion—mixture of gelatin and silver halide crystals; material in which x-rays or light interact with silver and transfer information.

gelatin—vehicle for holding silver halide crystals.

intensifying screen—device that converts x-ray energy into visible light.

interproximal (bitewing) film—small film with tab for patient to bite on, used in dentistry.

nonscreen (direct exposure) film—film sensitive to direct action of x-rays; should not be used with intensifying screens.

occlusal film—film used in dentistry for examining large areas.

periapical film—dental film.

polyester—plastic support for film emulsion.

radiolucent—permeable to radiation.

renogram film—small film individually packed in a plastic container; used during kidney surgery to study kidney function.

screen film—film sensitive to light from intensifying screen.

silver halide—light- and x-ray sensitive crystals of silver bromide and silver iodide used in film emulsion.

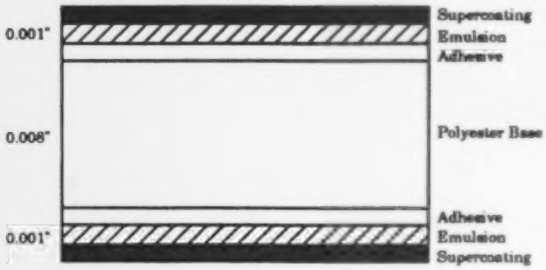
supercoating—protective gelatin layer over film emulsion.

Present-day x-ray film is an adaptation of photographic film developed in the 1960s. A present-day film is basically an accurately manufactured, transparent polyester plastic sheet (base), coated on both sides with a light-sensitive emulsion of gelatin and sensitized silver salts. Between the emulsion and the base is a thin coating of material to ensure uniform adhesion of the emulsion to the base. The emulsion is usually enclosed by a protective covering of gelatin, called the *supercoating*. This supercoating protects the emulsion from scratching (see fig. 1).

The Film Base

The *film base* is a blue-tinted, transparent sheet of polyester plastic, about 0.008 inch thick.

The base provides a support for the emulsion. It is flexible and unbreakable to allow easily handling, but is rigid enough to be placed on a view box. It is tinted blue to reduce eyestrain for the radiologist.



Cross-sectional View of Film

Figure 1

The Emulsion

The emulsion consists of microscopic crystals of silver halide suspended in gelatin. (Silver halide is 95 percent silver iodide.) The emulsion is approximately 0.001 inch thick. The gelatin is similar to that used in cooking except that the gelatin in film is of a higher quality.

During film manufacture, the gelatin is dissolved in hot water, and silver nitrate, potassium bromide, and silver iodide are added in total darkness. The principal sources of gelatin are the bones, cartilage, ligaments, and the hide of calves. In preparing the gelatin, a lime wash is used to remove fat and hair, and an acid wash is used to remove the lime.

This vehicle for carrying the silver salts in the photographic emulsion was chosen because of its properties. Gelatin does not dissolve in cold water; rather, it swells. When the water is heated, it dissolves, and more gelatin may be added. When the gelatin cools, the whole solution sets to a jelly. When reheated, it again becomes liquid.

This behavior makes it the ideal medium to carry the silver salts. They are added when the gelatin is in a heated, liquid state. When cooled and contracted, the silver salts are imprisoned within the internal cell-like structure of the gelatin. They will remain unaffected after the film is manufactured until it is exposed. When the film is immersed in a developer, the gelatin swells, opening pathways to the silver. This allows the developing solutions to act upon the silver.

The emulsion is spread on both sides of the polyester base. The entire process must be carried out in total darkness, from the time the ingredients are mixed together to form the emulsion until the finished sheet of film is packed in boxes.

Types of Film

Two main types of x-ray film are in use at the present time in medical radiography: (1) screen film and (2) nonscreen or direct-exposure film.

Screen film is most often used in radiography. Although sensitive mainly to the blue light emitted by intensifying screens, this film also responds to the direct action of x-rays. Screen film is used chiefly in cassettes with intensifying screens, a combination that has made possible the high speed and excellent quality of modern radiography. Although it is not very sensitive to the action of the direct exposure of x-rays, it may be used for radiography of small body parts, such as the hand.

Nonscreen or direct-exposure film has a thicker emulsion with more silver than in screen film. It is not so readily penetrated by light. Nonscreen film depends mainly on the direct action of x-rays during exposure and should not be used with intensifying screens. It is used to radiograph small body parts, such as a hand.

Dental films are a type of direct-exposure film and are available in different sizes and types. *Periapical film* for examining the teeth is packed in lightproof paper packets. *Interproximal (bitewing) film* in packets is used for locating cavities between the teeth and examining the relationship between upper and lower teeth. Film comes in a packet with a tab for the patient to hold in place by biting down. *Occlusal film* is used for examining larger dental areas that cannot be covered with the periapical film.

Renogram films are small x-ray films individually packaged in a plastic container shaped to fit around the kidney. They can be sterilized for use during kidney surgery. Radioactive iodine is injected intravenously.

A renogram records the rate at which the kidneys remove the iodine from the blood.

Dosimeter films were developed to measure high-energy radiation dosage. They are used in film badges for personnel monitoring.

Duplicating film is used to produce direct copies of medical radiographs. It has emulsion coated on only one side of the base.

Storage of Film

X-ray film is delicate and should not be handled carelessly or roughly. It is packed in a sealed metal foil bag and paper wrappings to protect it from light and moisture. It is packaged in quantities of 25, 75, or 100 sheets. The package is placed in a cardboard carton. Packed in this way, x-ray film will be free from any defects due to excess humidity, as long as it remains in the unopened foil wrapping.

Unexposed and unprocessed x-ray film should always be kept in a cool, dry place. High temperature causes loss of contrast and the production of fog. Unexposed x-ray film is not usable longer than a few weeks after subjection to temperatures of 90° to 100°F, or longer than a few days at 110° to 120°F. A relatively brief period of excessive heat in transit or storage may ruin the film, regardless of how well it is protected.

Sealed containers protect film from moisture and other contaminants as long as the package is unbroken. They do not protect against high temperatures. Ideal storage conditions are 40 to 60 percent relative humidity and temperatures of 50° to 70°F.

Film must be protected from the unwanted action of radiation by lead-lined walls or containers. Film bins located in the processing room should be protected by lead. X-ray film must never be stored in drug rooms or other places containing fumes of any kind. Film should never be subjected to extreme pressure, such as wrinkling or bending, because changes take place in the emulsion. Upon development, this causes artifacts to appear on the finished film. To avoid pressure markings, packages of unexposed x-ray film should always be stored on edge. They should never be stacked on top of one another. All film should be used before its expiration date. This date is located on the end of the box.

Film Holders

X-ray film, like photographic film, is sensitive to light. Because of this sensitivity, film must be protected by a lighttight holder until it has been exposed to x-radiation and processed. The holder must allow radiation to pass through while protecting the film from light.

A *cassette* is a lightproof container for holding film. Casettes are available in sizes to fit standard film: 14" x 17", 11" x 14", 10" x 12", 8" x 10", 6 1/2" x 8 1/2", 5" x 7", 7" x 17", and 9 1/2" x 9 1/2". A cassette is slightly larger than the film it holds and about one-half inch thick. The front is usually made of a lightweight metal or plastic, and the back and frame of aluminum or stainless steel. The back is hinged and contains one or more hold-down clamps. Felt gaskets around the edges ensure that the cassette is lightproof.

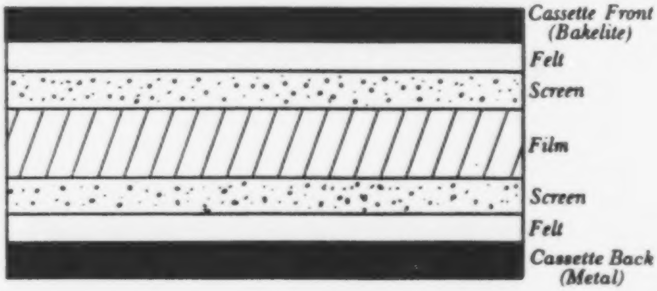
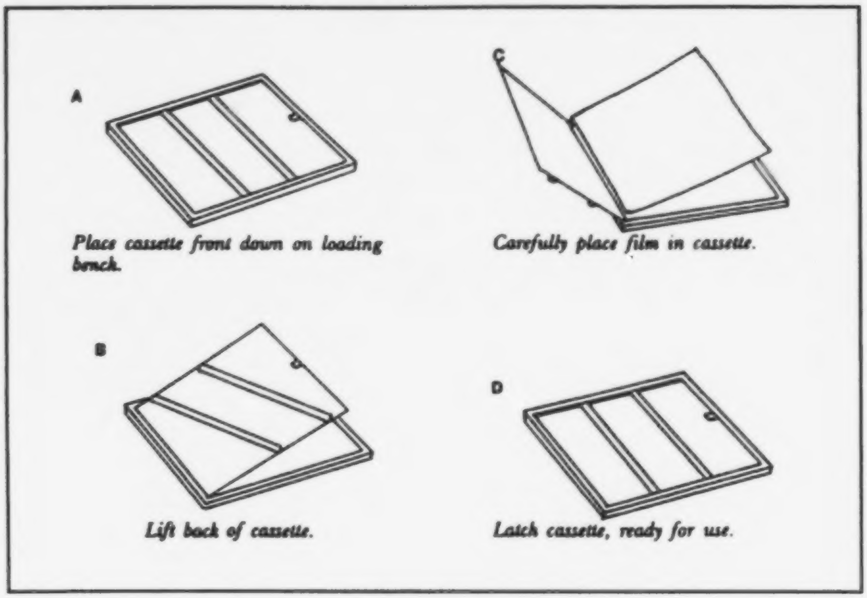


Fig. 2. Cross-sectional view of cassette containing film



Place cassette front down on loading bench.

Lift back of cassette.

Carefully place film in cassette.

Latch cassette, ready for use.

Fig. 3. Loading a cassette

Attached to the front and back inside covers of the cassette are intensifying screens. The screens convert the x-ray energy into visible light which exposes the film (see fig. 2).

To load a cassette, it is placed front down on the loading bench, and the back of the casette is lifted. The film should be removed slowly and carefully from the film bin. Being careful to keep the film straight, place it flat into the cassette. Then the back is closed, and the latches are locked (see fig. 3).

Extraoral dental radiographs require cassettes. Panoramic dental film must be contained in a cassette before it is placed in the x-ray machine for use in surveying dental arches. Profile radiographs are also used by orthodontists and require holders. Film used for intraoral x-rays usually does not require placement in a holder. Flat periapical dental film comes from the manufacturer as a paper-covered wafer ready for placement in a patient's mouth. For the interproximal or bitewing x-ray, the dental radiographer lifts the heavy paper flap, and the film, in a paper holder, can be placed in position.

The quality of the finished radiograph depends, in part, on the care in handling that the film receives from the time it arrives in the department until it is filed as a radiograph.

Summary

The chemical composition of film is presented. How the base provides support for the emulsion is described. Other topics include types of radiographic film and how these are placed in cassettes.

8

Intensifying Screens

Objectives: After completing this unit, you will be able to—

1. *state the purpose of intensifying screens;*
2. *describe the composition of intensifying screens;*
3. *name the types and characteristics of phosphors used in intensifying screens;*
4. *compare rare earth screens to calcium tungstate screens;*
5. *explain the screen cleaning procedure; and*
6. *describe the wire-mesh test for screen-film contact;*

Terms and Definitions

afterglow—continued emission of light from a phosphor after x-radiation is over; same as *phosphorescence*.

barium lead sulfate—phosphor used in high-speed intensifying screens.

calcium tungstate—phosphor used in intensifying screens.

detail—sharpness of the image on the radiograph.

intensifying screen—device that converts the energy of the x-ray beam into visible light; amplifier of the radiation reaching the film.

micron—unit of length equal to one millionth of a meter.

mil—unit of length equal to one-thousandth of an inch.

phosphor—the layer of an intensifying screen that converts the energy of the x-ray beam into visible light.

phosphorescence—continued emission of light from a phosphor after x-ray exposure is over; same as *afterglow*.

protective coat—plastic layer of intensifying screen that protects the phosphors from damage due to handling.

rare earth—special phosphors used in intensifying screens; some types glow with blue-violet light and other types with green light.

reflective layer—the layer of an intensifying screen that reflects light from the phosphor toward the film.

screen base—cardboard or polyester support of intensifying screens.

screen speed—the amount of exposure needed to produce a given amount of light.

The sensitivity of film to direct x-ray exposure is very low, so a very large dose of radiation to the patient is necessary for adequate exposure to the film. By the use of light in addition to x-radiation, the examination can be done with less radiation. For this purpose, an *intensifying screen* is used.

Intensifying Screens

X-ray intensifying screens are found in cassettes, and they correspond to the film sizes. The film is sandwiched between two intensifying screens. In most screens, there are four layers (see fig. 1).

The *base* serves as a support for the other layers. It is usually made of high-grade cardboard or polyester. The base is the layer farthest from the x-ray film.

The layer next to the base is the *reflective layer*. This layer reflects light going from the phosphor in the direction of the base back toward the film. It is made of a shiny substance such as titanium dioxide.

The active layer next to the reflective layer is the *phosphor*. The phosphor converts the energy of the x-ray beam into visible light. This can be demonstrated by placing an open cassette on the x-ray table directly under the x-ray

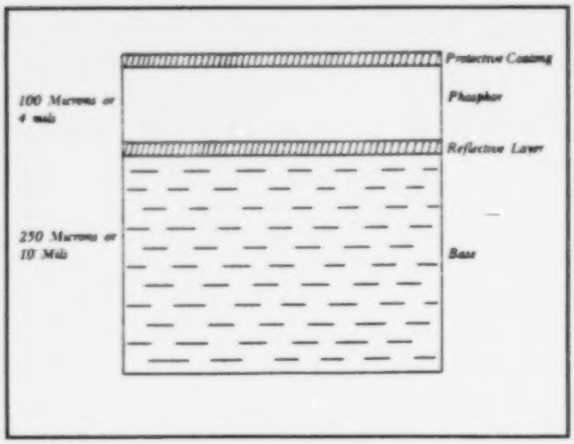


Fig. 1. Construction of intensifying screen

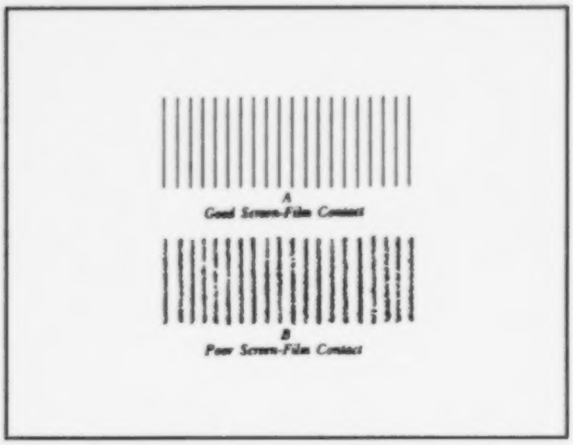


Fig. 2. Wire-mesh test

tube. When struck by x-rays, the screen will glow brightly. Several materials will glow when struck by x-rays, but only a few possess the necessary characteristics to be used in radiography:

1. The phosphor should give off a large amount of light.
2. The light must be of the proper color to match the sensitivity of the x-ray film.
3. The phosphor should have little or no afterglow (phosphorescence).

The materials used have been *calcium tungstate*, *barium lead sulfate*, and *rare earth*. Within a year after Roentgen discovered x-rays, Thomas Edison developed calcium tungstate intensifying screens. Calcium tungstate is still the most widely used phosphor today, although barium lead sulfate is used in some high-speed screens. Calcium tungstate and barium lead sulfate give off a blue-violet light when struck by x-rays. X-ray film is very sensitive to light in this color.

The principal advantage of rare earth screens over calcium tungstate is speed. The faster the screen, the less radiation exposure will be given to the patient. Some rare earth screens give off a blue-violet light while others can be manufactured that glow with a green light. If screens glow with a green light, it is necessary to use a film that is sensitive to green rather than to blue-violet color.

The layer of the screen closest to the film is the *protective coating*. This plastic layer protects the phosphors from damage due to handling.

Speed

Screens are classified not only by the type of phosphor used, but also by speed. For example, screens may be *detail* (slow), *par* (medium), or *fast*. A radiology department may use one speed of screen or several, depending on the type of work to be done. In general, a slower screen gives more detail, but it also gives more radiation to the patient.

Contact

To provide a radiograph with good detail, the screens must be in close contact over the entire film surface. To test the screen-film contact, a wire mesh is placed on top of a loaded cassette. An exposure is made, and the film is processed. If the image of the wire looks sharp and well defined, there is good screen-film contact. Should there be any areas of poor or no contact, the image of the wire will be blurred or fuzzy (see fig. 2).

Poor contact is caused by several factors, such as loose hinges on the cassette, a warped cassette, or worn felt in the cassette.

Screen Care

Care must be taken not to scratch the screens. Damage will be permanent and will detract from the quality of the radiograph. Screens must be cleaned often. Special screen-cleaning materials are available. If these are used, the manufacturer's directions should be followed carefully. Screens can also be cleaned with soap and water. Always use a soft cloth, cotton balls, or 4-inch gauze squares.

After cleaning, the screens should be dried thoroughly and left open for a time before reloading with film. If a film is placed against a damp screen, it may stick to the screen, causing permanent damage. Properly maintained screens should last for many years.

Summary

The purpose, composition, and care of intensifying screens are discussed in this unit.

9

Radiographic Darkroom

Objectives: After completing this unit, you will be able to—

1. *cite procedures performed in the darkroom;*
2. *identify necessary considerations when selecting the location of the darkroom;*
3. *describe the entrances that may be used for darkrooms;*
4. *explain the functions of the following: passbox, film bin, and safelight;*
5. *identify the filter generally used in safelights;*
6. *outline the procedure for testing a safelight;*
7. *describe how supplies are stored and replaced; and*
8. *explain how x-rays are marked for identification.*

Terms and Definitions

cassette—lighttight holder for film used during radiation exposure.
film bin—lighttight container for storage of unexposed film.
loading bench—work counter in darkroom to hold cassettes for loading and unloading.
pass box—cabinet for transferring cassettes between the radiographic room and the darkroom.
radiograph—x-ray film that has been exposed and processed.
safelight—light used for darkroom illumination during processing.

Proper processing is one of the most important functions in a department of radiology. Radiography begins and ends in the darkroom. A film may be ruined before the exposure is made. The efforts of a technologist using the most expensive radiographic machines may be destroyed by poor darkroom techniques.

The *darkroom*, or processing room, is the place where unexposed film is placed in lighttight holders, called cassettes, ready to be exposed. After the film is exposed to radiation, the cassette is returned to the darkroom where the film is removed and processed.

Location and Size

The darkroom should be conveniently located for the rooms it will serve. In most radiology departments, darkrooms will be located between two rooms; in a smaller department, one central darkroom may serve all radiographic rooms.

The size of the darkroom will vary according to the size of the department and the number of darkrooms in the department. The darkroom must be large enough to contain the automatic processor or manual tanks or both, an adequate-sized loading bench for loading and unloading cassettes, the film bin, and storage area.

The darkroom should not be so large that the darkroom technician has to walk a long distance between loading bench and processor, thus wasting space, time, and energy.

Entrances

The entrance to the darkroom must be lightproof so that the film will not be exposed by light leaking around a door. Several types of entrances may be used for darkrooms:

- The simplest arrangement, and the one most often used today, is the single-locked door. The door must be made lighttight by weatherstripping. It should have a lock on the inside so that it cannot be opened while films are being processed.

- Another type of entrance is a small hall with a door from the outside and one to the darkroom. These doors are interlocking; that is, they are electrically connected so that they cannot be opened simultaneously.
- Revolving doors similar to those in some office building and stores may be used satisfactorily when made lighttight. Although only a small space is used in this method, its design prevents removal and entrance of bulky equipment.

Arrangement

The manual tanks, automatic processor, loading bench, and other equipment and accessories should be thoughtfully located in order to make possible maximum output with ease and efficiency. The route to processing a film should move forward with no backtracking.

The darkroom should have a "wet" side and a "dry" side with no overlapping or backtracking. The **wet side** consists of the *manual processing tanks, automatic processor*, and a *sink*. The **dry side** includes the *film bins*, the *transfer cabinets or pass boxes*, and *compartments* for cassettes and other items characteristic of the department. Most of these will be a part of, or grouped around, the loading bench.

The *loading bench* is the work counter to hold casettes for loading and unloading. The bench should be 2 feet deep and about 3 feet high. The top should be covered with a material that will not chip, such as Formica or stainless steel. A grounded metal strip should be placed at the front of the bench to minimize static. The color should be selected so that film, which is green, can be seen under safelight illumination. Grey, maroon, and brown with designs or checks are good colors.

Below the counter should be shelves or partitions to store loaded cassettes and exposure holders in an upright position, but projecting enough for easy removal. They should all be on the same level to minimize stooping.

Protection

The walls of the darkroom should contain enough lead so as to provide protection from radiation to the technicians and to films. Care should be taken to see that all openings, such as those for pass boxes and intercoms, receive protection.

Color and Material

In addition to being radiation-proof, the walls must also be chemical-resistant. Ceramic tile is the best material because it is unaffected by chemicals, easy to keep clean, available in a wide variety of colors, and will last a lifetime. If the expense of tile prohibits its use, a chemical-resistant paint should be selected. The life of the best-painted walls is directly proportional to the cleanliness and care they receive.

In early years, the idea prevailed that darkrooms should be black. Later, the cheerful appearance of a room was given consideration. Since the outside light is to be excluded, there should be no light except from the safelight. If it is safe, then its illumination is safe when reflected. Because most x-ray films are more sensitive to the blue light in the spectrum, the safelights are usually in the red and orange color ranges. Maximum reflection is obtained if wall colors are ivory, cream, buff, or pale shades of any desired color.

The floors should be made of material that is durable, cleanable, and resistant to staining and chemicals. In addition, they should not be too slippery or hard on the feet. Ceramic or asphalt tiles are good for this purpose. Linoleum will become stained by developer and fixer solutions.

Ventilation

Good ventilation is important because of the objectionable chemical odors that can result when mixing solutions, and with old solutions.

Both the darkroom technician and the film should be given consideration when evaluating ventilation. Excessive humidity will cause the technician's hands to perspire which, in turn, will result in damaged film. Too little humidity will cause drying of the technician's skin and will also promote static in handling film. This will show up as black areas on the film.

The temperature should be maintained between 67° and 78°F, and the average relative humidity at 60 percent. Tanks should be covered, and floors kept dry. Central air conditioning is the best method of ventilation.

Illumination

The room should be provided with *white light* and *safelight*. The switches should be just inside the door when entering, with the safelight switch in the most easily accessible position. The white light is necessary for cleaning and for mixing chemicals. Safelights are standard, low-wattage white bulbs with a filter placed over the bulb. Their purpose is to provide enough illumination for darkroom personnel to work efficiently and, at the same time, not to damage the film.

The safelight should be carefully arranged to provide efficient, but not dangerous, illumination. A safelight may be placed in the center of the ceiling in a small darkroom, but a larger room will require additional lights over benches and closer to tanks.

For most film used in radiography, a red safelight filter, Wratten 6B, is recommended because it provides maximum visibility with minimum fogging. However, it is important to follow the film manufacturer's recommendations as to filter type, bulb wattage, and distance from light to film.

Test for Safelights

Film is approximately eight times more sensitive to safelight illumination after it has been exposed to radiation. The quality of the film may be damaged if it is left too long before being processed.

The safelight may be tested as follows: A film that has received a slight exposure to radiation is placed on the counter and covered with black paper. Each minute, the paper is slipped one inch from the short side of the film, and a large lead numeral is placed on the area, with safelight exposing it progressively until it reaches one inch from the opposite side. Develop it under standard conditions. The lead numbers in the test indicate the time at which fog, or graying, begins to appear.

Pass Boxes

Pass boxes or *transfer cabinets* should be built into the wall at appropriate locations, preferably above the loading bench. They should be lighttight and x-ray-proof, being provided with two interlocking doors so arranged that both cannot be opened at the same time. After the films are exposed, the cassettes are placed in the pass box through the outside door, and then removed through the inside door by the darkroom technician. The number of pass boxes required will be determined by the amount of work to be done. The doors of the pass box should be lead-lined, and a rubber mat should be on the floor to keep cassettes from slipping.

You should make a habit of placing the cassette in the transfer box in the same direction when sending it to the darkroom, and the darkroom technician should always return them in a uniform way. This helps ensure that the cassettes will not be accidentally opened by bumping together.

Film Bin

Opening out from under the loading bench should be the film bin, which is usually constructed of metal. The bin is made up of multiple divisions mounted on the front or door, sized to hold a box of 75 or 100 films. The bottoms of the slots are adjustable to maintain a uniform height for the tops of the film. Film is usually stored in order: 7" x 17", 14" x 17", 11" x 14", 10" x 12", 8" x 10", 6 1/2" x 8 1/2", 9 1/2" x 9 1/2".

The film package is designed to allow easy removal of the film from the box before placing it in the bin, if desired. A handle that is hinged to the base is placed on the front and may be pulled back to a stopping point about halfway to the floor. On the front, the words "UNEXPOSED X-RAY FILM—DO NOT OPEN IN WHITE LIGHT" should be placed. As a safety precaution, an electrical wiring system should be arranged so that the white lights go out automatically if the door to the bin is opened.

Storage

Shelves with doors can store chemicals, film, or other supplies. Film should always be stored lengthwise with the box on its side. An expiration date is stamped on the end of each box so that the oldest may be used first. This is important since film is expensive and cannot produce a diagnostic radiograph if used past its expiration date.

All chemicals should be labeled legibly and stored close to their area of use in an orderly manner. As supplies are used, replacements should be ordered. The assistant should follow the policy of the facility in calling a shortage to the attention of a supervisor or putting needs on a list. New supplies are usually placed to the back so that supplies close to an expiration date will be used first.

Film Identification

Radiographs must be accurately identified for each patient. The method used depends on the requirements of the radiology department. The method used may be exposing an identifying number, composed of lead numerals, on the film at the same time as the exposure is made on the patient.

Another method is to use a typed patient identification card indicating the patient's name, file number, name of hospital, date, and other pertinent information. The card and film are exposed together to a small source of white light in some type of identification unit.

A third method uses radiopaque tape. Patient information is typed on the tape. The tape is attached to the cassette before exposure.

Cleanliness

The importance of cleanliness in the darkroom cannot be overemphasized. To protect the films and chemicals, the room must be free from dust and dirt. It must receive the same maintenance as the rest of the department.

Any chemicals that have been spilled must be thoroughly removed because, after drying, their powder will be blown about. Smoking is prohibited because ashes can get inside a cassette and ruin a film. Eating in the darkroom can cause crumbs of food to become trapped inside the cassette and permanently damage it.

Summary

The location, size, arrangement, equipment, and maintenance of the radiographic darkroom are examined in this unit.

10

Processing Radiographs

Objectives: After completing this unit, you will be able to—

1. *compare the automatic method with the manual method;*
2. *list in order the steps in the manual process;*
3. *name and give the function of each chemical in the developer;*
4. *name and give the function of each chemical in the fixer;*
5. *describe and give the function of the following: transport system, water system, recirculation system, replenishment system, and dryer system;*
6. *explain how temperature affects processing;*
7. *describe how the replenishment process takes place;*
8. *demonstrate how film (in different sizes) is fed into the processor;*
9. *describe how emulsion swelling is controlled; and*
10. *list and describe methods for recovery of silver from the fixer.*

Terms and Definitions

acidifier—acid in fixer that stops development.

activator—chemical in developer that softens the film and lets reducing agents work efficiently.

developer—mixture of chemicals that makes the image permanent.

fog—unwanted overall grayness on the film.

glutaraldehyde—chemical in automatic processing developer that controls emulsion swelling.

hanger—metal device for suspending film in processing chemicals.

hardener—chemical that shrinks and hardens the film emulsion.

phenidone—chemical in automatic processing developer that acts as a reducing agent to build up gray tones.

preservative—prolongs life of processing chemicals.

reducing agent—chemicals in developer that change invisible image to a visible image by producing black and gray tones in the image.

replenisher—solution added to chemical developer to maintain activity and level.

restrainer—chemical in developer that keeps the developer from causing fog on the film.

silver recovery—removal of silver from used fixer.

solvent—liquid for dissolving processing chemicals.

A film that was exposed perfectly can be ruined through poor processing. *Processing* is a system used for developing, fixing, and washing x-ray film. Processing has two purposes. First, processing turns the invisible image present on film after exposure to x-radiation into a visible image. Second, processing makes that image permanent.

Two processing methods are used, manual and automatic. The manual method requires the technician to move film in a holder from processing tank to tank by hand. This method is encountered in small clinics and offices of dentists and veterinarians. The automatic method is used with large volume work in hospitals and clinics. An automatic processor has been developed especially for dental film.

Manual Processing

For the manual method, or hand processing, the darkroom technician must ready solutions by stirring and checking for volume and temperature. The exposed film is removed

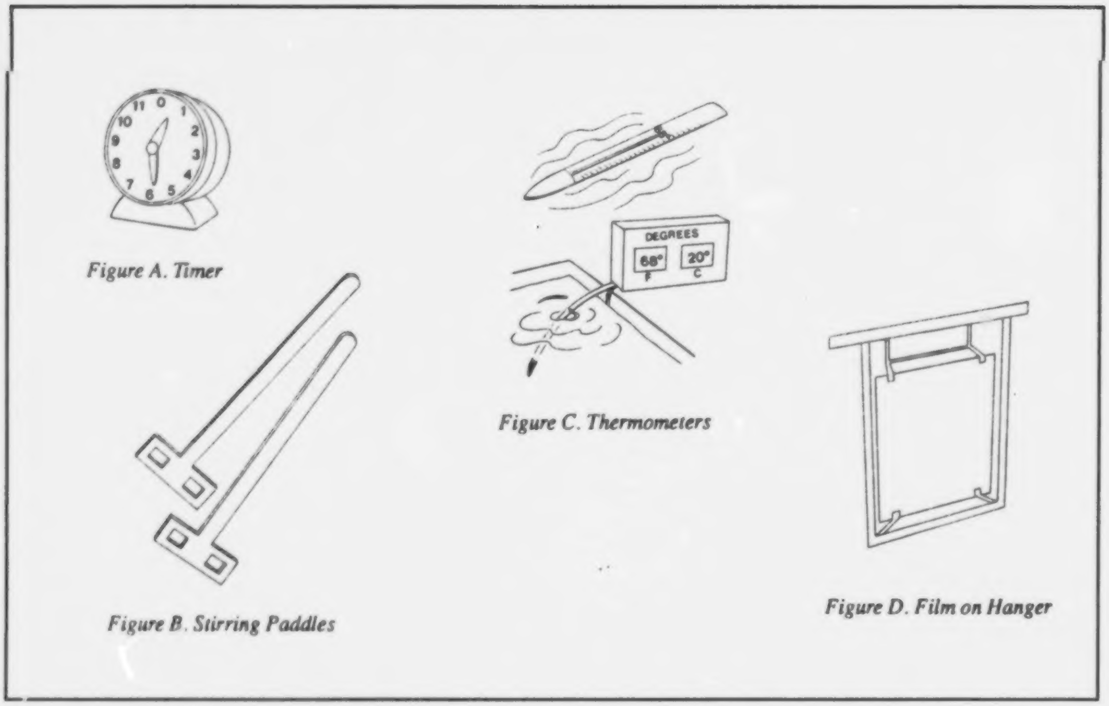


Figure A. Timer

Figure B. Stirring Paddles

Figure C. Thermometers

Figure D. Film on Hanger

Fig. 1. Equipment used in manual processing

from the cassette. The film end is placed into the bottom of a hanger, and the hanger is closed. The suspended film is immersed in developing solution for an exact amount of time. At a given temperature there is a correct developing time for each manufacturer's product. Most seem to agree that developing for 5 minutes at 68°F is best.

Next, the film (in its hanger) is removed from the developing solution. The film is put in a water bath or an acid bath for 30 seconds and agitated vigorously. Excess water is allowed to drain.

After this, the film is immersed in the fixing solution for a period of time. In the fixing bath, the surface is hardened, and the image is made permanent. After the fixing bath, the film is again washed, rinsed at least 30 minutes in a running water bath, and then dried in racks or in a dryer. The total process may take as much as 45 minutes to an hour. Figure 1 shows some of the equipment used in manual processing.

Advantages of Automation

There are many advantages to using automatic processing in the darkroom. First, it shortens total processing time to as little as 90 seconds, in contrast to one hour for the manual method (see fig. 2). Second, it improves quality control because of more accurate temperature regulation and more precise replenishment in the automatic processor. Third, it increases the capacity of the radiology department or office by expediting work flow.

Automatic Processing

The three main sections in an automatic processor are the *film feeding, film processing*, and *dryer sections* (see fig. 3).

The processor maintains the chemical solutions at the proper temperature, agitates the film as it passes through, replenishes the solutions automatically, and transports the films

	Manual	Automatic
	About 1 hour	90 seconds/1 1/2 minutes
Developing temperature	68°F	95°F
Fixing temperature	68°F	95°F
Washing temperature	68°F	98°F
Drying temperature	90-110°F	120°F
Developing time	3-5 min.	25 sec.
Fixing time	2-10 min	21 sec.
Washing time	15-30 min.	9 sec.
Drying time	15-20 min.	20 sec.

Fig. 2. Comparison of manual and automatic processing temperatures and times

mechanically at a carefully controlled speed throughout the cycle.

The processor is made up of several systems. These are the transport, water, recirculation, replenishment, and dryer systems.

The *transport system* serves several functions:

- Rollers move the film through the developer, fixer, wash, and dryer.
- The system keeps the film in each stage of processing for exactly the right length of time.
- The rollers agitate the film.
- The last few rollers in each section squeeze the solutions from the film.

The *water system* washes the film and keeps the solutions at the correct temperature.

The *recirculation system* mixes the replenisher solutions with the solutions in the processor. This system also helps keep the solutions at a constant temperature and keeps them in constant contact with the film. The solutions are pumped from the processor tanks and passed through devices to regulate temperature. Then the solutions are returned to the processing tanks.

The *replenishment system* is very important for film processing and the life of the processing solutions. When a film is fed into the processor, pumps are activated, and replenisher is pumped into the tanks. As soon as the film passes the entrance assembly, the pump stops. Therefore, replenisher is added in relationship to the length of the film.

The size of the film and the manner in which it is fed into the processor becomes very important. For example, a 7" x 17" film fed lengthwise will cause replenisher to be added as if film were 17" x 17". The film only uses up a small amount, and there is overreplenishment, which is wasteful (see fig. 4). Overreplenishment of developer may result in lower contrast and lower maximum density. Should underreplenishment occur, the film may lose contrast and density. This also results in poor fixation, poor washing, and, possibly, failure to transport the film through the remainder of the processor.

The *dryer system* dries the film in a short time. The film must be properly conditioned by adequate mixing of developer and fixer chemicals. Effective removal of surface moisture by the rollers is necessary when the film enters the dryer section.

The dryer must have a good supply of warm air to strike both sides of the radiograph in order to dry rapidly. Heated air is supplied to the dryer section by a blower. Most of the air is recirculated, and the rest is vented to prevent building up an excessive humidity in the dryer (see fig. 5).

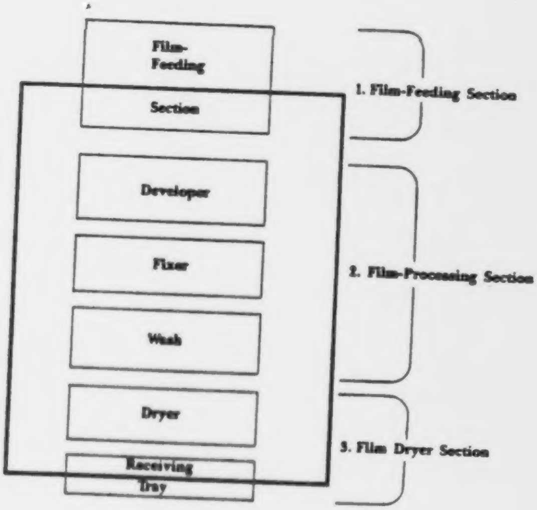

Film-
Feeding
Section
1. Film-Feeding Section
Developer
Fixer
Wash
2. Film-Processing Section
Dryer
3. Film Dryer Section
Receiving
Tray

Fig. 3. Sections of an automatic processor

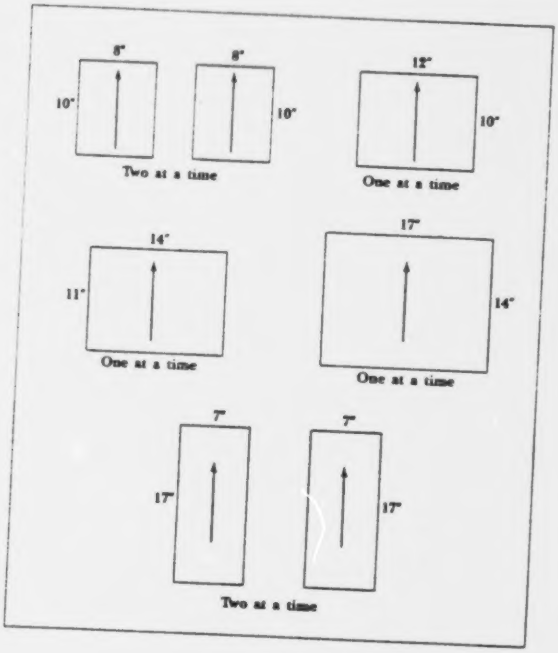

8"
8"
10"
10"
Two at a time
12"
10"
One at a time
14"
11"
One at a time
17"
14"
One at a time
7"
7"
17"
17"
Two at a time

Fig. 4. Feeding films into automatic processor

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Chemistry of Developing

Although the basic chemical principles used are similar in both manual and automatic processing, some of the solutions are different. In automatic processing, roller spacing was so critical that the swelling of the emulsion in the developer and its shrinkage in the fixer caused the films either to jam between the rollers or to wrap around them. As a result of much experimentation, manufacturers discovered the changes required to adapt the processing solutions to automatic processing:

1. Increased concentration of solutions to shorten the processing time in the various sections; drying time reduced.
2. Increased processing temperatures to help speed up processing. The temperature is kept at approximately 95°F for the developer and 120°F for the dryer. To combat chemical fog at these high temperatures, antifogging agents were added to the developer.
3. Hardening of the emulsion to prevent the film from sticking to the rollers. Special hardening chemicals were added to the developer.
4. Control of emulsion thickness to keep it as constant as possible throughout processing, permitting the use of constant spacing between the rollers. Compounds such as sulfates were added to the developer to minimize swelling of the emulsion.

Table 1 lists the chemicals used in processing. Variations between the two processes are indicated for developers. The fixers are the same for both.

Film Characteristics

The manufacture of films had to be conducted even more precisely than before to maintain constant thickness of the base and emulsion. Its curling tendency had to be eliminated to prevent the film from wrapping around rollers or being misdirected to the wrong rollers.

Stickiness of the emulsion had to be minimized to prevent the film from sticking to and wrapping around the rollers.

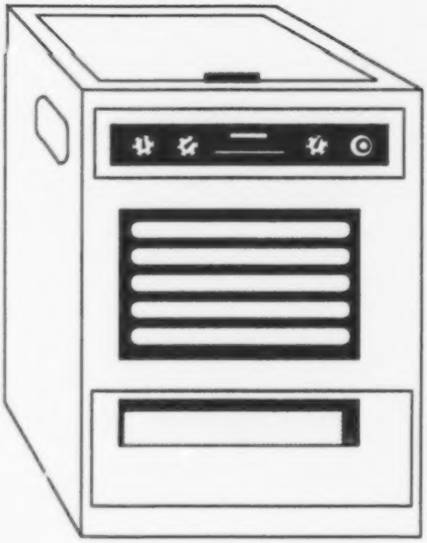

Fig. 5. The automatic film processor

Film used in 90-second processors has less gelatin than other films. The lower the ratio of gelatin to silver bromide in a film, the easier it is for the processing chemicals to get into the emulsion.

Care

For continuous, troublefree service, it has been proven that good housekeeping is essential. The rollers must be cleaned regularly and often. The developer and fixer tanks need to be emptied and cleaned after developing 50,000 films or at the end of three to four months, whichever comes first. Periodic inspection of the transport systems must be done to evaluate all major parts. Manufacturers' directions must be strictly followed.

Silver Recovery

As described in an earlier unit, radiographic film contains silver halide. As the film is developed, the silver halide becomes black metallic silver in the areas exposed to radiation. When the film is placed in the

TABLE 1
Chemicals Used in Automatic and Manual Processing

A. *Developers* used in both processes unless specified

General Function	Chemical	Special Function
reducing agents	phenidone (A) metol or elon (M) hydroquinone	quickly builds up gray tones slowly builds up black tones
activator/ accelerator	sodium carbonate or sodium hydroxide (A)	swells and softens the emulsion so that reducing agents may work more effectively
hardener	glutaraldehyde and sulfates (A)	controls emulsion swelling to allow better transportation of films through processor
restrainer	potassium bromide	keeps the reducing agents from causing fog
preservative	sodium sulfite	prolongs life of developer
solvent	water	liquid for dissolving chemicals

B. *Fixers* used in both processes

General Function	Chemical	Special Function
fixing agent	ammonium thiosulfate	dissolves the unexposed, underdeveloped silver crystals on film
acidifier	acetic acid	stops development by neutralizing developer
hardener	aluminum chloride, chrome alum, or potassium alum	shrinks and hardens emulsion
preservative	sodium sulfite	prolongs life of fixer
solvent	water	liquid for dissolving chemicals

fixer, the unexposed, underdeveloped silver is cleared from the film, and the image becomes permanent.

The silver cleared from the film is deposited in the fixer solution. Removing the silver from the fixer is known as *silver recovery*. Silver recovery from used photographic processing solutions is becoming increasingly important for several reasons: conservation of a natural resource, increasing profits by selling silver, and prolonging the life of the fixer.

Several methods for silver recovery may be used. *Metallic replacement* is a method of silver recovery by chemically replacing silver with another metal. It consists of a recovery cartridge and a circulating unit and will recover all silver in the fixer solution. *Electronic recovery* uses an electric current between positive and negative electrodes placed directly in the fixing tank or in a separate tank in which used fixer is collected. When solutions are funneled directly from an automatic processor into an electrolytic recovery unit, a broken connection in the form of an air gap must be provided to prevent plating of silver in the processor. The electronic recovery method has advantages of low initial cost, improved efficiency, and no required maintenance.

A third method is *chemical precipitation*. Compounds are added to used fixer to precipitate silver in the form of a sludge. This method can result in the release of fumes that can damage sensitized products. Fixing baths treated in this manner must first be removed from any area where film is handled.

No matter how small the radiology department, silver recovery can help defray part of the cost of processing.

Summary

Manual and automatic methods of processing are explained and compared. The steps in processing are listed along with the chemistry of the process. Feeding film correctly into the automatic processor is illustrated. Reasons for and methods of silver recovery are presented.

11

Artifacts

Objectives: After completing this unit, you will be able to—

1. *explain how artifacts are caused by improper handling;*
2. *describe the artifacts produced during manual processing;*
3. *describe the artifacts produced during automatic processing;*
4. *point out how artifacts can be caused by defective film holders; and*
5. *identify additional factors contributing to production of artifacts.*

Terms and Definitions

artifact—any foreign or artificial mark on a radiograph.
contaminate—to soil by contact; to make inferior or impure.
exhausted—deprived of a valuable quality.
oxidize—to combine with oxygen.
pi—mathematical symbol denoting the ratio of the circumference of a circle to its diameter; value of 3.14159265.
tacky—sticky to the touch.

Artifacts are any foreign or artificial marks that are placed on a radiograph because of improper film handling, improper processing, or faulty equipment. The prime cause of artifacts is carelessness.

There are four basic groups of artifacts. These may result from handling, manual processing, automatic processing, and other equipment problems leading to unsatisfactory radiographs.

Handling

The first of the categories is handling. Included in this group are the following:

- *Crescent marks*—half-moon-shaped densities caused by the film being bent, creased, folded, or subjected to pressure.
- *Static marks*—branching black marks or smudge patterns caused by low humidity, cold temperatures, rough handling, or ungrounded equipment.
- *Smudge marks*—dense, black areas of different sizes and shapes caused by either fingerprints from wet hands or finger abrasions.
- *Scratches*—thin, clear areas caused by accidental removal of the emulsion from scraping the film against a sharp object, the side of a processing tank, or a film hanger clip.

Manual Processing

The second group of artifacts are those produced during manual processing. Examples of this group are these:

- *Chemical fog*—an overall grayish density on the radiograph with no distinctive pattern; caused by overdevelopment, contaminated solutions, or high processing temperatures.
- *Brown stain*—brownish appearance on the radiograph, caused by using an oxidized developer.
- *Yellow stain*—a yellow appearance on the radiograph, caused by inadequate rinsing or using an exhausted fixer.
- *Frilling*—a curly or wavy appearance on the edges of the film caused by exhausted fixer and the water or solution temperature being too high.
- *Air bells*—small, round spots that are clear and less dense than the rest of the

radiograph, caused by air bubbles adhering to the emulsion during development.

- *Drying marks*—white, patchy blemishes on the film caused by inadequate film drainage between washing and drying or overheating of the drying unit.
- *Water marks*—round, dark spots of various sizes caused by droplets of water on the film surface.
- *Kiss marks*—clear areas of green-white blemishes on the film caused by films touching while in the solutions.
- *Streaks*—either dark or light lines on a radiograph caused by insufficient agitation, pressure fog, irregular drying, or splashed solutions on dried film.
- *Reticulation*—network of fine grooves or cracks in the film surface caused by marked differences in temperature of processing solutions—for example, a hot developer and a cold fixer.

Automatic Processing

Automatic processing artifacts are the third group. The use of automatic processors has resulted in these artifacts:

- *Uneven spots on film*—uneven sheen on the surface of the film (some areas dull, others shiny) caused by poor squeeze action of the first two or three pairs of dryer rollers.
- *Greasy or shiny appearance of the film*—improperly washed; water not turned on.
- *Drying streaks*—caused by either dirt in the dryer or improper positioning of the air tubes.
- *Gritty film*—a sandpaper surface on the film caused by contaminated wash water.
- *Fogged film*—a grayish appearance caused by light leaks, unfastened cover of the wet section of the processor, contaminated solutions, or chemical imbalance.
- *Streaks*—caused by dirty rollers, dirty wash water, or film not being hardened sufficiently.
- *Wetness and tackiness*—caused by lack of acid in the fixer, inadequate replenishment of fixer, or drying temperature that is too low.
- *Pi line*—called pi line because a line occurs on the film 3.14 times the diameter of the roller away from the leading edge of the film; caused by fresh chemicals.
- *Yellow smudges*—due to improper fixation because of exhausted fixer solution.
- *Mottling*—a wavy pattern in the emulsion over the entire film caused by excessive developer concentration or temperatures.

Equipment

Examples of the fourth group of artifacts are those caused by defective or improperly maintained film holders:

- *Light fog*—a black or gray hazy appearance on the film; caused by loose hinges, worn springs, or felt on cassettes.
- *White specks*—pinhead-size white dots on the radiograph caused by dust or dirt on the intensifying screens of caSsettes.
- *Fuzzy image*—mainly produced by poor screen-film contact or defective screens.

Some other artifacts should be mentioned:

- *Fuzziness or lack of details*—motion of the patient, x-ray tube, or film during exposure; poor contact with intensifying screen due to soiling or wear.
- *Brittleness*—a deterioration of the film caused by excessive hardening in the fixer and excessive drying temperature or time.
- *Emulsion damage*—emulsion torn away from base of film caused by films sticking together in the drying process. Attempts to separate the films produce this artifact.
- *Fog*

  (a) *Light*—may occur when the darkroom is not lightproof, the safelight contains too large a bulb, the safelight housing or filter is cracked, the safelight filter series is incorrect, or the exposure of the film to the safelight is prolonged, especially at short distances.

(b) *Radiation*—films should be shielded by lead to prevent radiation fog during an exposure.

(c) *Chemical*—overdevelopment or development of film at excessively high temperatures; oxidized, deteriorated developer, which may also stain the film (oxidized developer is brown); prolonged or repeated inspection of films during development; and contamination from corroded tanks all deteriorate film.

(d) *Age*—either mottled or uniform fogging results from using outdated films, or from storing film under conditions of high temperature and excessive humidity.

The artifacts mentioned in this unit can produce needless repeats. Only through conscientious efforts toward proper maintenance, use of good darkroom procedures, and careful handling of film and film holders can these problems be eliminated.

Summary

For presentation in this unit, artifacts are arranged in groups according to whether handling, manual processing, automatic processing, or equipment caused their appearance. Under these headings, a specific artifact is listed together with its probable cause or causes.

Glossary of Radiographic Terms

abdominal echogram—ultrasound study of the organs in the abdominal area.

air contrast enema examination—patient is given a small amount of barium to coat the colon walls, and then air is injected to distend the colon for visualization.

angiogram—one of a series of x-rays of blood vessels taken after injection of a radiopaque substance. Angiograms may be aortic, cardiac, cerebral, or vertebral.

aortogram—x-ray of the aorta after injection of a radiopaque substance.

arteriogram—visualization of an artery after use of a contrast medium.

arthrogram—radiogram of a joint using contrast media.

barium enema examination—patient is given an enema of a barium solution to visualize the colon on x-ray.

bronchogram—x-ray of bronchial tree including the lungs.

chest film—routine x-ray of the chest; is posterio-anterial and/or lateral.

cholangiography—visualization of the bile ducts after introduction of a radiopaque substance.

cholecystogram—radiogram of the gallbladder.

cineangiocardiography—use of motion picture film to record heart structure and movement.

cinecystogram—motion picture of urinary system function, especially the bladder, using a radiopaque material.

contact scanning—ultrasound studies done with direct skin contact through a coupling gel.

cystogram—x-ray of urinary bladder.

discogram—use of contrast media injected into a vertebral disk to produce an image.

echogram—photograph produced by ultrasound techniques.

echocardiogram—visualization of internal structures of the heart by ultrasound.

echoencephalogram—visualization of brain structure by ultrasound.

flat plate—x-ray of a body part or foreign object in tissue without use of radiopaque materials.

gynecologic ultrasonograms—use of ultrasound to detect abnormalities of the female reproductive system, fetal placement, or presence of lesions.

hepatic echogram—ultrasound photograph of the liver.

intravenous pyelogram (IVP)—radiographic examination of the urinary system using a radiopaque contrast medium.

KUB (kidney, ureter, bladder)—flat plate of abdomen to show urinary system without use of contrast media.

laminogram or tomogram—x-ray appears as a slice (layer) through the tissue under study.

lower gastrointestinal examination or *barium enema*—a series of radiograms to visualize the colon after administration of a contrast medium.

lymphadenogram—use of a contrast medium to visualize a lymph node on an x-ray.

mammogram—x-ray of the breast.

myelogram—injection of a radiopaque dye or air to visualize the spinal cord and spinal canal.

nephrogram—radiographic study of kidneys; may be used to compare them with each other.

nephrotomography—sections of the kidney through body section scanning.

obstetric ultrasonograms—sonograms showing fetal abnormalities and placement.

pancreatic echogram—ultrasound study of the pancreas.

pelvic pneumogram—radiographic studies of the pelvic area after the injection of carbon dioxide into the peritoneal cavity.

pelvimetry—use of radiographic studies to determine obstetric measurements of the female pelvis.

pneumoarthrogram—radiogram using air injection into the joint for visualization and evaluation.

pneumocystogram—x-ray of the bladder after the introduction of air into it.

radioiodine uptake study—oral administration of radioactive iodine for studies of the thyroid gland in nuclear medicine.

renal sonogram or *nephrosonogram*—use of ultrasound to visualize the kidneys.

salpingiogram—use of a radiopaque dye for x-ray study of the fallopian tubes.

scan—imaging done in nuclear medicine by the deposit of a radionuclide.

a. *photoscan*—recorded on x-ray film.

b. *scintigram*—record produced when a radioactive substance in introduced into the body and scanned; intensity varies due to the amount of substance accumulated in body tissues.

c. *scintillation scan (scintiscan)*—pattern recorded by a scintillation counter to determine presence of neoplasms or lesions.

scout film—a screening or preliminary x-ray of any area before administration of contrast media; may be used to rule out or include certain diseases.

sonogram—photographic image produced by ultrasonography.

splenogram—x-ray of the spleen.

spot film—small area x-ray taken during fluoroscopy of a specific structure.

tomography—image produced by moving x-ray tube an film in opposite directions during exposure to provide a clear image with blurred supporting structures.

ultrasonogram (Doppler)—using ultrasound to measure blood flow.

upper gastrointestinal examination (upper GI series)—a series of radiograms to visualize the upper digestive tract after administration of a contrast medium.

ureterogram—x-ray of a ureter.

urethrogram—x-ray of the urethra and may include the prostate.

urogram—radiograms of the urinary tract using radiopaque materials.

venogram—visualization of a vein by use of a contrast medium.

ventriculogram—using an injection of air to visualize the ventricles of the brain.

xeroradiogram—using a selenium-coated plate for a radiogram and developing the plate without liquid chemicals.

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TX92CD04

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Student Learning Activities

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By

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Published by

The University of Texas at Austin
Educational Resources
Extension Instruction and Materials Center
Division of Continuing Education

1992

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Printed in the United States of America

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Stock Number HO 220 LA

Contents

Foreword..v

Acknowledgments...vi

Unit 1 / The Radiologic Technologist as a Member of the Health Care Team......1

Unit 2 / The Production of X-Rays...7

Unit 3 / Equipment...11

Unit 4 / Protection from Radiation and Infection...........................17

Unit 5 / Radiology Office Records and Procedures.........................23

Unit 6 / Patient Care and Transportation..27

Unit 7 / Radiographic Film and the Film Holder...............................31

Unit 8 / Intensifying Screens...39

Unit 9 / Radiographic Darkroom...43

Unit 10 / Processing Radiographs...47

Unit 11 / Artifacts..55

Foreword

Assisting in Radiology/Imaging is designed for use by students investigating the activities within the radiology department or considering any of the imaging technologies as a career. The material is designed to relate training experience to information studied in the classroom. Information is provided which is current and relevant to the essential elements approved by the Texas State Board of Education, 1988. The material is designed for individualized study and is competency-based with objectives or outcomes stated for each unit. *Assisting in Radiology/Imaging* is made up of three separate publications.

- The *Student's Manual* contains learning objectives, terms and definitions, and information relating to current techniques and technologies. Clinical use of radiation; procedures for film loading and development, and types of equipment are presented. Both radiation and biological safety are emphasized. New imaging technologies, such as ultrasound and magnetic resonance, are introduced.
- The *Student Learning Activities* are individualized and designed to encourage the student to carefully read and study the information presented. Instructors are encouraged to provide one set for each student to facilitate learning.
- The *Instructor's Guide* provides a list of essential elements correlated to the units of instruction. A basic test is provided for each unit. Instructors are encouraged to enlarge these. Answers to tests and learning activities are included. A section has been added for those students desiring a more advanced study of each unit. A competency chart is included.

Acknowledgments

The Extension Instruction and Materials Center wishes to acknowledge with grateful appreciation the cooperation and assistance of the following health occupations teachers and professionals who served as members of the 1991-92 Health Occupations Project Advisory Committee:

- Jeanne Ballard, Education Coordinator for the Medical Laboratory, Seton Hospital, Austin, Texas
- Gail Beard, former HOE Educator, Houston, Texas
- Pam Buchanan, Lecturer for Kinesiology and Health, The University of Texas at Austin
- Fran Donohue, Health Occupations Educator, Victoria High School, Victoria, Texas
- Brenda Luckie, Coordinator for Ancillary Services, Student Health Center, The University of Texas at Austin
- Linda Montgomery, Health Occupations Educator, Brenham High School, Brenham, Texas
- Ann O'Sullivan, Radiology Technologist, Capital Radiology, Austin, Texas
- Carolyn Ragland, Instructor, Austin Community College, Riverside Campus, Health Sciences/Medical Laboratory Technology, Austin, Texas
- Judy Rose, Health Occupations Educator, Stephen F. Austin High School, Austin, Texas
- Barbara Selke-Kern, Director, Educational Resources, EIMC, The University of Texas at Austin
- Spanky Stephens, Head Athletic Trainer, Men's Intercollegiate Athletics, The University of Texas at Austin

Special thanks go to the Radiology Department, Memorial Medical Center of East Texas, Lufkin, Texas, for suggestions to update Table 1, "Preparations for Radiographic Examinations"; to Bev Brack, Radiologic Technologist, Blinn College, Brenham, Texas, for her comments on film size and chart forms; and to Charlotte Rutherford, R.T., Houston, Texas, for information included in the Glossary of Radiographic Terms.

The Center also recognizes with gratitude the support and suggestions provided by Barbara Terrell, State Program Director for Secondary Health Occupations Education, Texas Education Agency, Austin.

Portions of this book are adapted from Extension Instruction and Materials Center's 1984 publication, *Assisting in Radiology,* written by Janet Schnauze.

Learning Activity 1
Questions to Answer

UNIT 1
The Radiologic Technologist as a Member of the Health Care Team

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Directions: Write answers to the following questions.

1. Define *confidential communication*.

2. When should a radiographer discuss the findings of the radiologic examination?

3. Is it proper for the radiographer to discuss the pathology as shown on the radiographic examination with hospital personnel?

4. If a patient asks the radiographer for a diagnosis of the radiographs just taken, what should the radiographer do?

5. To whom do radiographs belong?

6. If a patient, upon being discharged from the hospital, comes by the radiology department for the radiographs she has had taken while a patient, what do you do?

7. Who establishes the policies and goals of a hospital?

8. Diagram a hospital organizational chart.

9. Name health professionals to be included on the health care team.

10. Diagram an organizational chart of a radiology department. Then add to the blanks the names of personnel in the facility where you work or observe.

11. Name two occupations included in the support staff of a hospital radiology department.

12. From which six fields could a person choose who is interested in a career in radiology or imaging?

13. Point out the reason that dentists use x-rays in dentistry.

Learning Activity 2
Word Recognition

UNIT 1
The Radiologic Technologist as a Member of the Health Care Team

Directions: Match by placing the letter of the definition in the blank next to the term it defines.

____1. chief radiologist

____2. chief technologist

____3. dental assistant

____4. nuclear medicine technologist

____5. physician

____6. radiation therapy technologist

____7. radiologic technologist

____8. radiologist

____9. department administrator

____10. sonographer

a. supervises overall departmental operations

b. uses ultrasound equipment to produce pictures for diagnosis

c. performs examinations that require administration of radioactive substances

d. a doctor who uses radiation to diagnose and treat diseases

e. exposes and develops dental x-rays

f. prepares patients for examination and treatment and operates x-ray equipment

g. assists the radiologist in administering radiation for treatment

h. supervises staff of radiology department

i. health professional who performs examinations, diagnoses, and treats disease

j. director of the radiology department

Directions: Give the meanings of these abbreviations.

11. CT
12. MRI
13. N.M.T.
14. R.T.
15. R.T.(A.A.R.T.)

Directions: Use *Introduction to Special Health Technologies* and Texas Health Career's publication on *Financial Aids and Educational Programs* as references. Locate the address of the place closest to you to secure information on careers in the health care areas listed. Write the addresses below. Select one that interests you the most, and write to that address for entry requirements and courses studied to complete the technology program.

Radiologic Technologist

Nuclear Medicine Technologist

Radiation Therapy Technologist

Diagnostic Medical Sonographer/Ultrasound Technologist

Magnetic Resonance Imaging Technologist

Directions: Write answers to the following questions.

1. When were x-rays discovered and by whom?
2. Describe the manner in which x-rays travel and their speed.
3. How are x-rays produced?
4. Of what is the target of an x-ray tube composed?
5. Determine the efficiency of x-ray production, and explain what happens to the remainder of the energy.
6. Name the three major parts of the x-ray tube.
7. Differentiate between the anode and cathode.
8. What is the purpose of the focusing cup?
9. Tell why the stationary anode in an x-ray tube is embedded in copper.
10. Name two types of x-ray tubes, and tell which is most commonly used.
11. Which generator control selects the amount of current to the filament of the x-ray tube?
12. Which generator control selects the penetrating ability of the x-ray beam?
13. List eight properties of x-rays.

Directions: Match by placing the letter in the diagram next to the part of the tube that identifies it.

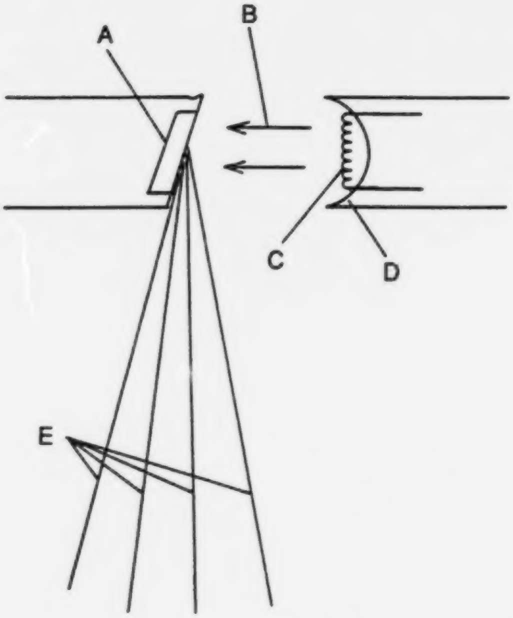
____1. focusing cup

____2. electrons

____3. x-rays

____4. filament

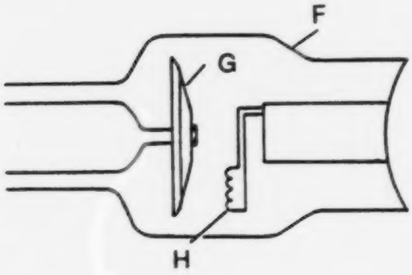
____5. target



____6. glass envelope

____7. filament

____8. rotating anode



9. What type of x-ray tube is shown in the upper drawing?

10. What type of tube is shown in the lower drawing?

Directions: Answer these questions using Unit 3 as a reference.

1. Name the four components of a radiographic unit.
2. What is the purpose of the tube stand?
3. Describe three types of tube stands.
4. Which component of a radiographic unit contains the equipment the radiographer uses to change the x-ray tube output?
5. Describe three factors that may be adjusted by a radiographic control panel.
6. What is the purpose of the generator?
7. Explain why contrast media are used. Name three contrast media.
8. What is the purpose of fluoroscopy?
9. What is a spot film?
10. When may a mobile unit be used?
11. What is the advantage of tomography over routine radiography?
12. Who first developed computerized scanning?
13. Compare the images recorded by tomography with those recorded by computerized scanning.
14. On which two imaging units would one expect to find a gantry? Compare these gantries.
15. On what types of persons is magnetic resonance imaging contraindicated?
16. List the major parts of an ultrasound machine.
17. Define the term *transducer,* and explain how ultrasound probes serve as transducers.
18. Explain why the camera used in nuclear medicine may be called either a gamma camera or a scintillation camera.

Directions: Add the correct word or phrase to the blank.

1. Barium sulfate, air, and iodine are commonly used for ____________________.

2. In fluoroscopy, the ____________________ brightens the image from 1,000 to 3,000 times over conventional fluoroscopic screens.

3. __________ allows several persons to view the fluoroscopic screen at the same time.

4. ____________________ units allow the radiologist and radiographer to remain outside of the fluoroscopic room during the examination.

5. A technique involving moving the x-ray tube and film in opposite directions during the exposure is known as ____________________.

6. In CT scanning, the x-ray tube and the detectors are contained in the ______________.

7. The ____________ is the component in MRI which sorts information and produces images.

8. In sonography, the probe is actually a ____________________.

9. The recorded image from an ultrasound machine is the __________________.

10. _______________ is the ability to give off light.

11. If body fluids are withdrawn for testing after a patient receives a radioactive substance, a ______ will be used for testing.

12. The invisible radiation given off during disintegration of radioactive elements is ____________________.

13. The ________________ plane divides the body into front and back.

14. The ________________ plane divides the body into right and left halves.

15. The ________________ divides the body into top and bottom sections.

Learning Activity 3
Comparison of Technologies

UNIT 3
Equipment

Directions: Select the information from the unit to answer these questions.

1. The image used for diagnosis in radiology may or may not be an x-ray. Some are photographs. Different technologies are listed below. Indicate what the diagnostic image is called (*name*). Several names may be appropriate. Tell whether it is an x-ray or a photograph or both (*type*).

	Name	*Type*
a. radiology		
b. fluoroscopy		
c. tomography		
d. computed tomography		
e. magnetic resonance imaging		
f. sonography		
g. nuclear medicine		

2. List three technologies that require a computer for image formation.

a.

b.

c.

Directions: Write answers to the following questions.

1. Differentiate between the two types of damage caused by radiation exposure.
2. Using the formula MPD = 5(N-18), determine the maximum permissible dose for a technologist 25 years of age.
3. Using the formula MPD = 5(N-18), determine the maximum permissible dose for a technologist 40 years of age.
4. List the techniques that present the greatest danger of radiation exposure to personnel.
5. Name two personnel monitoring systems.
6. Where should the radiation monitoring devices be worn?
7. Identify the material most often used for shielding. Give another term used to describe this type of shielding.
8. Besides shielding, what two factors are involved in radiation protection?
9. State the inverse square law.
10. Name three articles of protective apparel that should be worn during fluoroscopy or mobile radiography. Of what are these made?
11. Tell why radiology personnel should never hold patients for radiographic examinations.
12. How are patients immobilized if radiology personnel do not hold them?
13. Name the two legislative acts that provide for standards for medical x-ray equipment and for licensing of medical personnel.
14. What two federal agencies have authority to regulate materials used in radiology?

Learning Activity 2
Word Recognition

Directions: Match the terms to the phrases, using letter answers.

____1. somatic effect

____2. immobilization device

____3. MPD

____4. chromosome

____5. rem

____6. film badge

____7. genetic effect

____8. barrier

____9. dosimeter

____10. TLD

____11. scattered radiation

a. thermoluminescent dosimeter

b. shield of radiation-absorbing material or materials to bar disease

c. structure in a cell that transmits genetic information

d. instrument resembling a fountain pen, used to measure accumulated radiation dose

e. exposure to radiation causing possible deformity in future generations

f. unit of measurement of radiation exposure for humans

g. maximum permissible dose

h. contains small film used to measure radiation dose

i. equipment used to prevent movement

j. effect produced when x-ray beam bounces off tissues

k. radiation damage to cells and tissues

Learning Activity 3
Medical Asepsis

Directions: Answer these questions.

1. Define these terms:
   a. medical asepsis
   b. communicable disease
2. How are sanitation and asepsis complicated in the hospital setting?
3. List and explain three ways by which disease can be spread.
4. Describe methods by which radiology personnel may protect themselves from infection.
5. Cite times that the hands should be washed.
6. Discuss the use of gloves, gowns, and masks in the x-ray department.
7. What is the major responsibility when one-use supplies are employed?
8. Compare the two types of barriers encountered in the radiology department.

Directions: Answer these questions.

1. List three duties of radiographic office personnel.
2. What should the person answering the telephone in the radiology department say?
3. Differentiate between *verbal* and *nonverbal* communication.
4. Explain why the radiology personnel who make appointments should be familiar with the examination procedures.
5. Who must order all radiographic examinations?
6. When a request for a radiographic examination is received, what is done first?
7. Explain how a report on a radiograph is prepared.
8. How many copies of the report are made? Indicate to whom or where these go.
9. In the digital filing system, what determines how radiographs are filed?
10. In large radiology departments, what type of record-keeping system is used?
11. Select the words from the "Terms and Definitions" which are part of or refer to the digestive system. List these.
12. Select the words from the "Terms and Definitions" which are part of the urinary system. List these.

Directions: Write answers to these questions relating to procedures.

1. Name the contrast material that is usually given for a GI series.
2. Name the ingredient in the contrast material used for gallbladder studies and intravenous pyelograms that makes the organs visible.
3. What is the name of the examination used to demonstrate the kidneys?
4. Explain the purpose of a mammogram.
5. Point out precautions to be observed for CT scanning.
6. Describe the process of emission scanning used in nuclear medicine.
7. What symptoms indicate an allergic response to contrast media?
8. Explain the process associated with lithotripsy.
9. For what is the ultrasound examination used most often?
10. List other parts of the body frequently imaged by ultrasound.
11. For what is echocardiology used?
12. What advantage do you see in the use of Doppler ultrasound?
13. Would you choose MRI over CT scanning? Why or why not?
14. Match the patient preparation to the examination by placing the letter in the blank.

_____(1) GI series	a. No solid food but lots of liquid the day before exam. Castor oil at noon on day before exam. 8 oz. water each hour in afternoon before exam and x-ray prep at 6:00 P.M. Clear water enema at 5:00 A.M. (2 quarts)
_____(2) gallbladder examination	b. 2 1/2 oz. x-ray prep at 6:00 P.M. on day before exam No solid foods on exam day Small amounts of fluid on day of x-ray
_____(3) barium enema	c. Nothing by mouth after midnight

____(4) intravenous pyelogram	d. Gallbladder tablets taken with water at about 9:00 P.M. On day before exam, no solid food after evening meal and only sips of water after 10:00 P.M.

15. Below are listed body structures or medical conditions. Specify which procedures might be selected for use on the structure or for the condition.

Structure / Condition	*Procedure / Procedures*
a. breast	
b. circulatory system	
c. digestive system	
d. gallbladder examination	
e. head	
f. heart conditions	
g. female pelvis	
h. male pelvis	
i. pregnancy	
j. thyroid gland	
k. transplanted organ	
l. urinary system	

Directions: Answer the following questions.

1. Name ways of determining the patient's name to be sure that you have the right patient.

2. When working with an injured person, from which side is clothing removed first? Which side is dressed first?

3. Why is it important for the technologist and aide to follow the rules of good body mechanics?

4. What is the point at which the mass of a body is centered? Relate the line of gravity to this point.

5. State four general rules for good posture.

6. List five rules of body mechanics.

7. Describe how directions should be given to patients.

8. Name three ways of moving patients.

9. Describe in four steps how to place a patient in a wheelchair.

10. List three methods of assisting a patient to walk.

11. If a patient should begin to fall, what should the technologist do?

12. What should the patient be told under these circumstances?

    a. The requested x-rays have been taken.

    b. Film must be repeated.

13. Once the radiologic examination is completed, what steps are taken to dismiss the patient?

Learning Activity 2
Recognition of Words

Directions: Match the terms to the definitions, writing a letter in the blank.

____1. body alignment
____2. gravity
____3. balance
____4. trunk
____5. ambulation
____6. base of support
____7. supine
____8. body mechanics
____9. center of gravity

a. lying face upward
b. walking
c. proper body alignment, movement, and balance
d. stability
e. center for body mass
f. body apart from head and extremities
g. attraction of a mass to the earth
h. parts in proper relationship to one another
i. portion of the body that is in contact with the floor
j. lying face downward

Directions: Circle the correct answer.

10. To provide a good base of support for the body, the feet are placed parallel and very close together/a few inches apart.

11. Improper body alignment and balance causes muscle strain/efficient muscle functioning.

12. When moving a patient, always transfer the person across the shortest/longest distance.

13. Lock/unlock all wheels on a stretcher when moving a patient from the stretcher to the x-ray table.

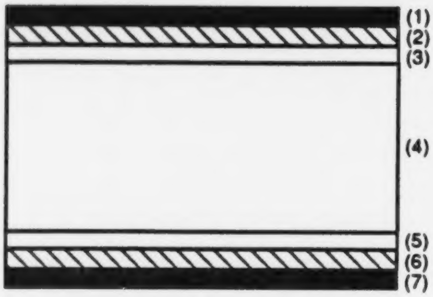
14. Give the patient short, simple/long, detailed commands when you wish him or her to move.

15. An imaginary line passing through the center of gravity is known as the trunk/line of gravity.

Directions: Label the numbered parts of each diagram shown below.

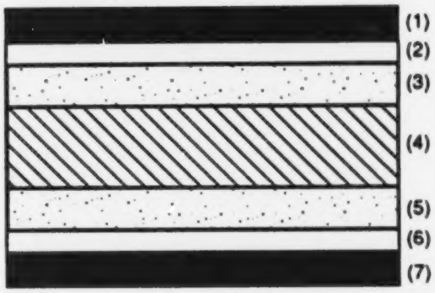
1. Cross-sectional view of radiologic film

(1) ______
(2) ______
(3) ______
(4) ______
(5) ______
(6) ______
(7) ______



2. Cross-sectional view of a cassette containing film

(1) ______
(2) ______
(3) ______
(4) ______
(5) ______
(6) ______
(7) ______



Directions: Answer the following questions.

1. What are the basic components of x-ray film?
2. The layers shown on the diagram in Learning Activity 1 are listed below. Describe each layer. Give the depth of the base and emulsion layers.
   a. base
   b. adhesive
   c. emulsion
   d. supercoating
3. Why is the film base tinted blue?
4. What are the two main components of the emulsion?
5. Why is gelatin used in the emulsion?
6. List and differentiate between the two types of film used most often in radiography.
7. Which type of film is used in dentistry?
8. Explain the use of the following types of film:
   a. renogram film
   b. dosimeter film
   c. duplicating film
9. Describe the packaging of x-ray film. Be sure to include the quantities in a package.
10. Explain the environmental factors for consideration in film storage.
11. Where is the film expiration date found?
12. What is a cassette?
13. Of what are cassettes composed?

14. List available sizes of film.

15. What is the purpose of the felt gaskets?

16. State the purpose of the intensifying screens attached to the cassettes.

17. Describe the procedure for loading a cassette.

Learning Activity 3
Word Recognition

UNIT 7
Radiographic Film and the Film Holder

Directions: Circle the letter of the word or term that completes the sentence.

1. The protective gelatin layer over film emulsion is the
   a. supercoating
   c. intensifying screen
   b. base
   d. adhesive

2. A lightproof container for holding film is a
   a. folder
   b. cassette
   c. latch
   d. shelf

3. Film permeable to radiation is said to be
   a. transparent
   b. radiopaque
   c. radiolucent
   d. extraoral

4. A device for converting x-ray energy into visible light is the
   a. intensifying screen
   c. polyester
   b. periapical film
   d. supercoating

5. The plastic support for film emulsion is made of
   a. gelatin
   b. polyester
   c. silver halide
   d. felt

6. The single-coated film used to make copies of radiographs is called
   a. dosimeter film
   c. bitewing film
   b. extraoral film
   d. duplicating film

7. The light and x-ray sensitive crystals used in film emulsion are
   a. silver chloride
   c. silver halide
   b. bromide emulsion
   d. silver nitrate

8. The flexible, blue-tinted support for emulsion is called the
   a. felt
   b. base
   c. cassette
   d. emulsion

9. The vehicle for holding silver halide crystals is
   a. polyester
   b. a cassette
   c. silver bromide
   d. the gelatin

10. Film used in film badges to measure radiation dosage is
   a. periapical film
   c. duplicating film
   b. renogram film
   d. dosimeter film

11. The film used in dentistry to examine large areas is
    a. periapical   b. bitewing
    c. occlusal   d. interproximal

12. Dental film for locating cavities between teeth is called
    a. interproximal   c. periapical
    b. occlusal   d. renogram

Directions: Talk with your supervisor in the facility where you work to answer these questions.

1. Determine what type of film is used and who manufactures it.
2. List film sizes provided for use.
3. Who orders the film for the department?
4. Who is responsible for keeping the film inventory at the proper level?
5. How is the reorder point determined?
6. Describe the types of film holders used.
7. Evaluate the facilities provided for film storage. Be sure to determine whether optimum environment is provided for film storage.
8. Do you have any suggestions for improving film storage?

Learning Activity 1
Study Questions

UNIT 8
Intensifying Screens

Directions: Answer the following questions.

1. What is the purpose of an intensifying screen?
2. Explain how the use of intensifying screen benefits the patient.
3. How many intensifying screens are there for one film?
4. Name two materials that can be used for a screen base.
5. What is the purpose of the reflection layer?
6. Of what is the reflection layer composed?
7. What is the reflective layer composed?
8. List three characteristics a phosphor must possess to be used in radiography.
9. Name three materials used as phosphors in intensifying screens, and tell what colors each screen will glow from that material.
10. Cite the advantages of rare earth screens over calcium tungstate.
11. What is the purpose of the protective coating?
12. By what two factors are screens classified?
13. What advantage does a fast screen give?
14. Explain the advantage of good screen contact.
15. How may screen-film contact be tested?
16. List factors causing poor contact between screen and film.
17. How should a screen be cleaned?
18. In the place where you work, what phosphor is used in the intensifying screens?

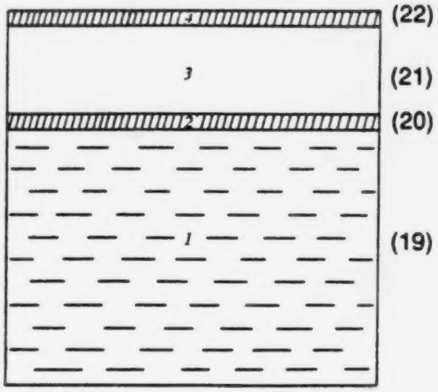
Directions: Label the cross-sectional diagram of an intensifying screen by writing the name of the layer next to the number.

19. ______________________________

20. ______________________________

21. ______________________________

22. ______________________________



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Learning Activity 2
Word Recognition

UNIT 8
Intensifying Screens

Directions: Match the definition to the word, and write the letter in the blank.

____1. afterglow

____2. detail

____3. calcium tungstate

____4. micron

____5. mil

____6. phosphor

____7. phosphorescence

____8. rare earth

____9. reflective layer

____10. screen base

____11. screen speed

a. continued emission of light from a phosphor after x-ray exposure is over

b. phosphor used in intensifying screens

c. layer of intensifying screen that converts x-ray energy into visible light

d. layer of an intensifying screen that reflects light from the phosphor toward the film

e. amount of exposure needed to produce given amount of light

f. most widely used phosphor for intensifying screens

g. sharpness of image on x-ray

h. unit of length equal to one-thousandth of an inch

i. polyester support of the intensifying screen

j. unit of length equal to one-millionth of an inch

Directions: Write short answers to the questions.

1. Name two types of entrances that may be used for radiographic darkrooms.
2. Name two items found on the "wet" side of the darkroom.
3. Name two items found on the "dry" side of the darkroom.
4. Why is the loading bench grounded?
5. How are darkrooms protected against radiation?
6. What material is best for darkroom walls and floors?
7. Name a color that would be suitable for darkroom walls.
8. State the ideal temperature and humidity for the darkroom.
9. What type of safelight filter is generally used in radiographic darkrooms?
10. Is film more sensitive to safelight illumination before or after exposure to radiation? How much more or less?
11. How may a safelight be tested?
12. Where is the film expiration date found?
13. Why is it important to use film before its expiration date?
14. Name three methods of identifying a radiograph.
15. Draw a rough sketch to show the placement of equipment in a darkroom in the facility where you work.

Directions: Match by writing the letter of the definition in the blank next to the term.

____1. radiograph

____2. cassette

____3. darkroom

____4. pass box

____5. safelight

____6. film bin

____7. loading bench

____8. transfer cabinet

a. lighttight holder for film used during exposure to x-ry

b. lighttight container for storage of unexposed film

c. work counter in darkroom to hold cassettes for loading and unloading

d. x-ray film exposed to radiation and processed

e. cabinet for transferring cassettes from radiographic room to darkroom

f. light used for darkroom illumination during processing

g. place for processing film

Learning Activity 1
Word Recognition

UNIT 10
Processing Radiographs

Directions: Circle the letter of the word that best completes the sentence.

1. Solution added to chemical developer to maintain its activity and level is the
   a. acidifier b. replenisher
   c. activator d. preservative

2. The mixture of chemicals to make the image permanent is the
   a. preservative b. restrainer
   c. developer d. activator

3. Liquid for dissolving processing chemicals is a
   a. solvent b. developer
   c. phenidone d. restrainer

4. The system for developing, fixing, and washing x-ray film is
   a. activating b. silver recovery
   c. processing d. replenishing

5. Unwanted overall grayness on film is
   a. solvent b. phosphor
   c. hardener d. fog

6. For shrinking and hardening the film emulsion, use a/an
   a. hardener b. phenidone
   c. activator d. acidifier

7. The chemical that softens the film and lets reducing agents work effectively is the
   a. agitator b. activator
   c. acidifier d. restrainer

8. A metal device for suspending films is the
   a. paddle b. timer
   c. hanger d. bath

9. A system to prolong the life of processing chemicals is the
   a. acidifier b. hardener
   c. preservative d. restrainer

10. The chemical in developer that changes invisible images to a visible image by producing black and gray tones in the image is the
    a. fog b. reducing agent
    c. hardener d. restrainer

Directions: Answer these questions.

1. Name two methods for processing film.
2. How is developing time determined in the manual process?
3. State the generally accepted time and temperature for developing film.
4. List the steps in manual development.
5. Cite three advantages of automatic processing over manual.
6. List the three main sections of an automatic processor.
7. Name the five systems of an automatic processor.
8. At approximately what temperature are these sections maintained?
   a. developer
   b. fixer
   c. dryer
9. Which of the five systems moves the film through the processor?
10. Describe the use of water in processing.
11. Explain how the following film is fed into the automatic processor.
    a. 7" x 17"
    b. 11" x 14"
    c. 8" x 10"
    d. 10" x 12"
12. What happens when film is fed incorrectly into the automatic processor?
13. What must be accomplished by the transport system before the film enters the dryer?
14. Explain how the film is dried.
15. Why is the thickness of the emulsion on film important?
16. Describe the characteristics film should possess for use in automatic processors.
17. Discuss ways to keep an automatic processor troublefree.

Directions: Below are listed sections of the automatic processor. Match each to its function. Write the letter of the function in the blank next to the section.

____18. transport system

____19. water system

____20. recirculation system

____21. replenishment

____22. dryer system

a. maintains solution level and concentration

b. circulates warm air to dry film

c. removes excess liquid by squeegee action

d. keeps fresh solution in contact with the film

e. washes film and keeps solutions at correct temperature

Directions: Answer these questions.

1. From what chemical is the silver recovered?
2. In which processing unit is the recovery of silver made?
3. What are the advantages to silver recovery?
4. List and describe three methods used to recover silver.
5. Which method of silver recovery can recover all of the silver in the fixer?
6. Which method is usually used in automatic processing?

Directions: Indicate whether the chemical listed is used in developing (D) or fixing (F). Give both its general and special functions.

Chemical	*Use (D or F)*	*General Function*	*Special Function*
1. acetic acid			
2. aluminum chloride			
3. ammonium thiosulfate			
4. chrom alum			
5. elon			
6. glutaraldehyde			
7. hydroquinone			
8. phenidone			
9. potassium alum			
10. potassium bromide			
11. sodium carbonate			
12. sodium hydroxide			

13. sodium sulfite			
14. water			

Learning Activity 1
Study Questions

Directions: Write answers to these questions.

1. What is an artifact?
2. What is the prime cause of artifacts?
3. Name the four basic groups of artifacts.
4. What type of artifact occurs when the film is (a) bent or creased? (b) scraped against a sharp object?
5. What type of artifact is caused by marked differences in the temperature of processing solutions?
6. How does the film appear if the water in the automatic processor has not been turned on?
7. What type of artifact will occur if the automatic processing rollers are dirty?
8. What is a *pi* line, and what causes it?
9. List all of the factors that cause film to fog.
10. What is the name for a condition of overall grayish density on the radiograph caused by overdevelopment, contaminated solutions, or high processing temperatures during manual processing?
11. What causes brown stains on a radiograph?
12. What causes yellow stains on a radiograph?
13. Name the artifact caused by films touching while in the solutions in manual processing.
14. What term is applied to film with a sandpaper surface caused by contaminated wash water?
15. In automatic processing, what conditions are caused by a drying temperature that is too low or lack of acid in the fixer?
16. What causes pin-sized white dots on a radiograph?
17. List two causes for a fuzzy radiographic image.

18. A box of film is left in the procedure room during an exposure. What may happen to it?

19. What effect does excessive drying temperature or time have on film?

20. If attempts are made to separate film which stuck together during drying, what may be damaged?